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Devoted to Marine Oil Engine and Motor Vessels

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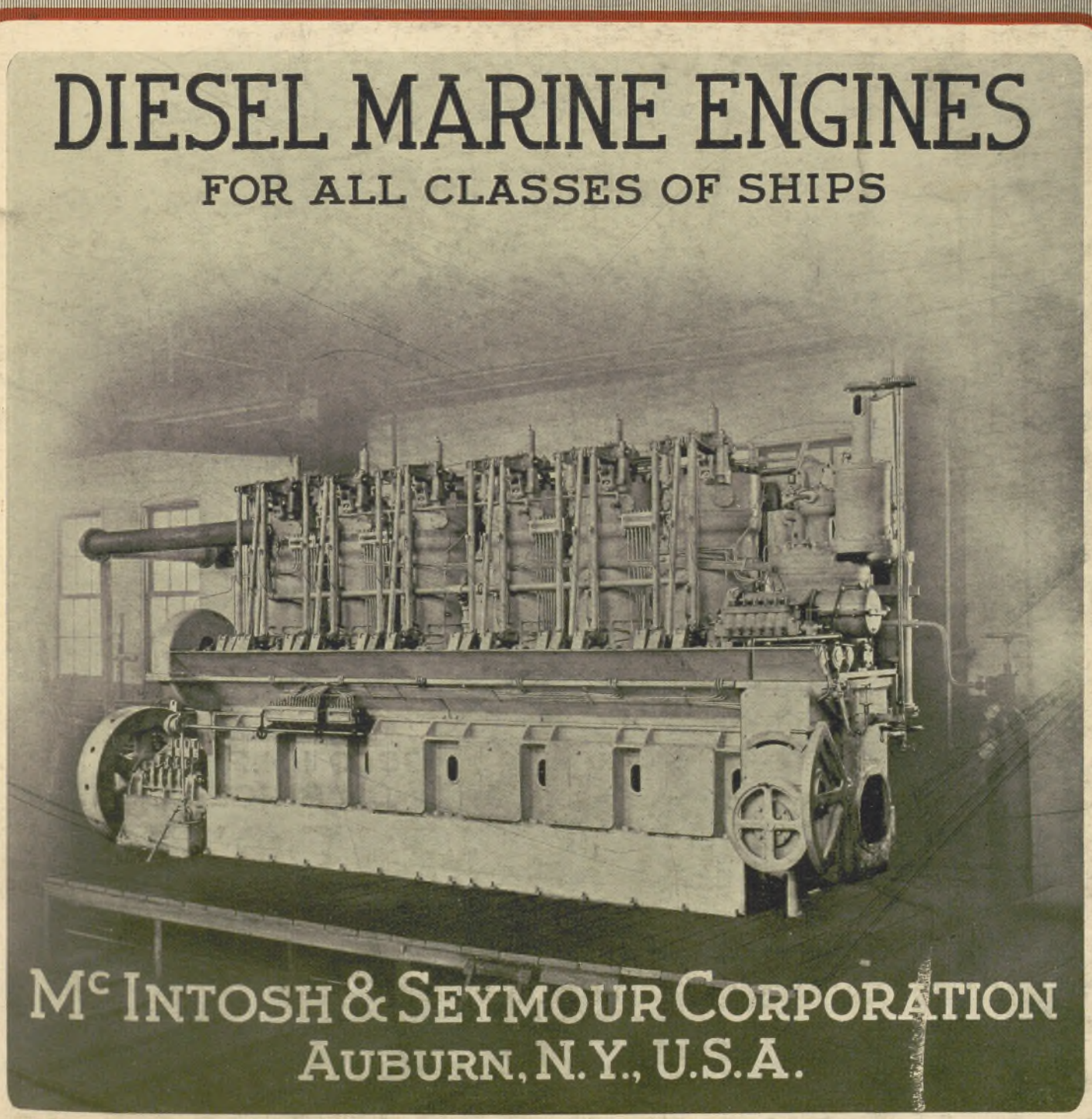
DIESEL MARINE ENGINES
FOR ALL CLASSES OF SHIPS



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EXCLUSIVE technical and non-technical articles on design, construction and operation of oil-engines and motorships by the world's foremost writers on marine engineering.

MOTORSHIP

PROFUSELY illustrated with photographic reproductions of the newest designs in international merchant motorship and Diesel-engine construction and auxiliary equipment.

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Conversion of Steamer "Frank Lynch"

Interesting Installation of a Pacific-Werkspoor Diesel Engine in a Great Lakes Type Vessel

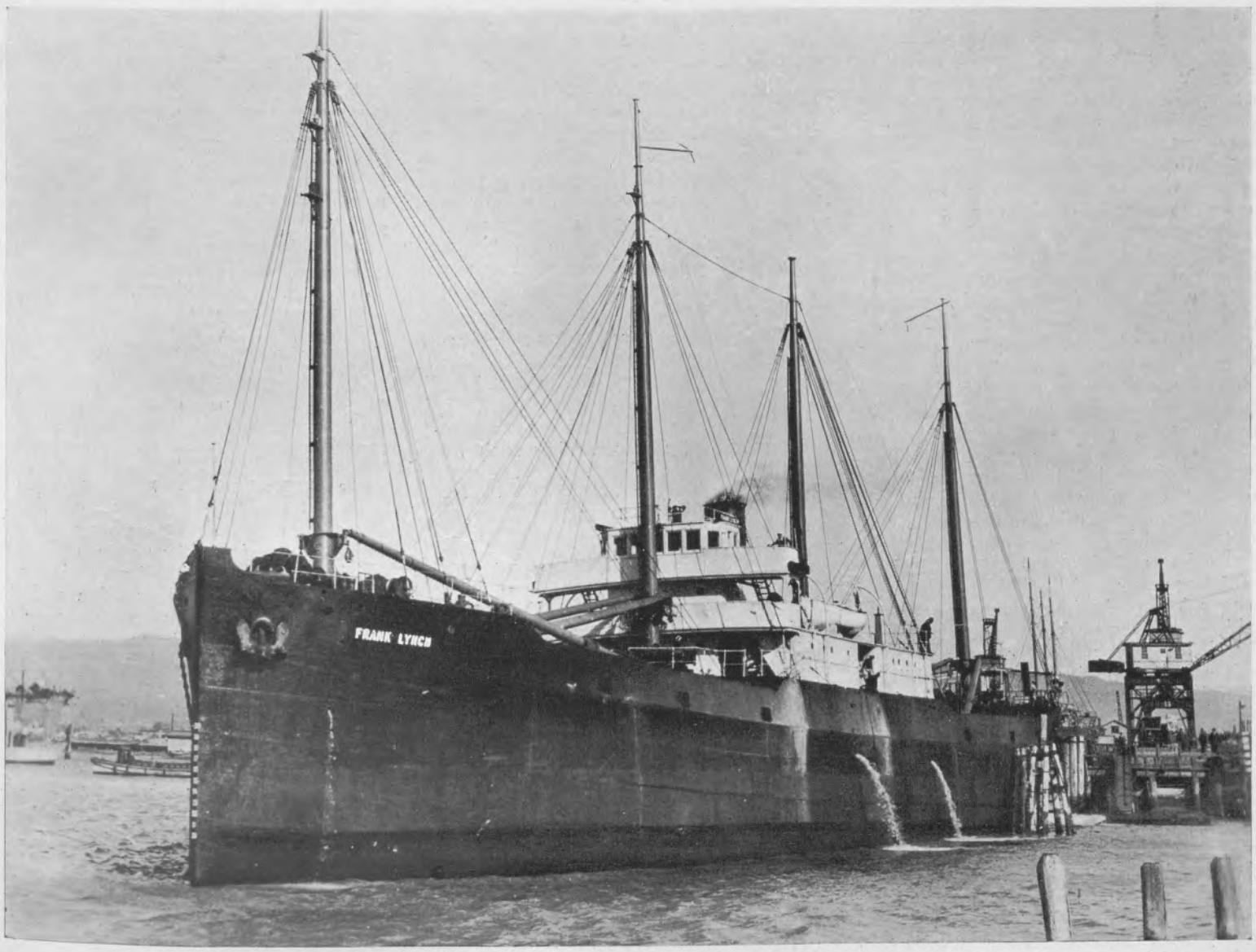
THE conversion of the FRANK LYNCH, formerly the LAKE SUNAPEE, from a steam-driven cargo vessel to a Diesel-driven lumber carrier, necessitated some changes which are believed to have set a new precedent in American marine practice. The ship's stern frame was cut and the tail-shaft boss was lowered nearly two feet without placing her in the drydock; two bulkheads were replaced by web frames; and provision was made for utilizing the exhaust-heat from her new engine in a donkey-boiler which furnishes steam for the auxiliaries.

The FRANK LYNCH was one of the Lake-type cargo vessels constructed for the Shipping Board by the Toledo Shipbuilding Company. Her new oil engine is an 850 s.h.p. Pacific-Werkspoor Diesel, and the work of installing it and rearranging the vessel was carried out by the Union Construction Co. of Oakland, California.

First the old engine and boilers were removed, and the fore peak, forward double-bottom tanks and forward cargo hold were filled with water. Thus weighted down forward, her stern frame was nearly clear of the water and the work of lowering the tail shaft was carried out. The stern frame was cut at points just above the old boss and somewhat below the location of the new one. A new section was cast and fitted, then welded in place.

This weld presented a problem in that it was necessary to make allowance for shrinkage due to cooling after the weld, in order to prevent internal strains in the stern frame. To overcome this, the frame was spread about five-eighths of an inch with jacks, and after the final weld the contraction of the metal was allowed for by gradually reducing the pressure of the jacks.

The old stern tube and tail shaft were used in the new installation. The bulkheads between holds No. 1 and 2, and 3 and 4 were cut out and replaced by deep web frames with heavy center pillars, in order to maintain the necessary stiffness. The space amidships occupied by the boiler and engine rooms, as well as the wing coal bunkers, was all thrown into the new engine room.



The "Frank Lynch," just converted from steam to Pacific-Werkspoor Diesel power to the order of W. J. Gray Co., San Francisco

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The new seating for the main engine was installed and the floors below were strengthened. The piping to the double bottom tanks was rearranged to permit of carrying either oil or water ballast. Thus as the oil is used it is replaced with water in order to preserve the proper trim. This arrangement gives a greatly increased cruising radius over her former arrangement, the owners estimating that she can carry enough fuel for a round trip between the Pacific Coast and Australia.

A donkey-boiler was installed in the forward end of the engine room on the starboard side. This boiler furnishes steam to all the ship's auxiliaries. When in port, steam is generated by an oil fire, a "Dahl" oil-burning system being used. When running at sea, steam for the steering engine and generator is generated by heat from the exhaust gas from the main engine. This is accomplished by having a water-cooled butterfly valve in the exhaust pipe. By this valve, the gas is directed either thru the silencer and up the stack, or thru the boiler. The gas is introduced into one furnace thru a special casting which enters the furnace thru an opening in the air plate above the oil-burning front. Then it passes thru the furnace, combustion chamber, and tubes, and up thru the uptake and stack the same course that would be followed by the gas from an oil fire. The furnace front, breeching, and uptake were all made tight with asbestos gaskets at the joints, and the latter was made unusually stiff to resist the vibration caused by the beating of the exhaust gas.

A new steam-driven compressor, a transfer pump, an independent air pump and a feed pump were also installed. On the port side of the engine-room were located the three air starting bottles, two fuel oil service tanks, and a small lubricating oil tank.

Changes in the cargo handling equipment included the removal of the old masts and six cargo posts, and replacing them with four new masts each carrying two seventy-foot booms. To operate these, eight winches of large capacity were installed in place of the old winches which were too small for the loads required. The entire job was completed in approximately two months' time.

The Pacific-Werkspoor Diesel engine is of the crosshead, single-acting, four-cycle, direct-reversible type, with six cylinders 20.472" bore and 35.433" stroke, and has an output of 1,150 i.h.p. or 850 shaft h.p. at 135 shaft h.p.r.p.m. It weighs 148 tons or 349 lbs. per shaft h.p. and has a length of 38' 5".

The "Bottom Line"

Reaching the Costs Per Unit of Pull in a Hypothetical Tow Line

By JOHN H. BARNARD

HISTORY is full of the setbacks to progress from those to whom the means and the methods of the past are almost holy. History is filling up with those who so rebel against such mental attitude that they resemble the dog in Aesop's Fables that dropped the piece of meat in his mouth to seize the reflection of that same piece of meat in the stream he was crossing.

Invariably real progress arises from mental traits which are scorned by those of both extremes. The truly wise are never too well satisfied with that which they have to refuse to consider the *new* but they do refuse to scrap the *old* until they have taken full measure of the new, and quite generally the old forms for them the best of yard sticks for this purpose.

With this in view, it would seem well for the proponent for that which is new, and known to him to be good, to go slow in decrying against so-called mental inertia. Instead, it should be recognized that inertia is, likewise, a storage of energy which might better be usefully directed and that good tactics dictate the furnishing of the preferred means of measuring towards encouraging self-starting.

May it not be too truly the fact that there has been lack of proper attempts along such lines? Has there not been too much insistence upon this, or that, argument and in a spirit of holding that the ship owner is mentally slow if he cannot see that such, or such, means of propulsion is the panacea for all the ills which beset an owner in this land of the free and the home of the dry?

Of course any "wising" the owner would be poor dope could the new means not stand rigid comparison with the means to be replaced, but, that not being the case, what fault can lie with any method for aiding a general understanding of the pros and the cons and in a display of confidence by all that, in the same, each will get his share and that in cases where his offerings will show to best advantage?

To this end there is proposed a form of "balance sheet" to constitute the yard stick before mentioned. By such a measure all who would study for themselves the art of ship propulsion can conduct a *costless* series of experiments which cannot fail to give them a clearer conception of what may be expected from forms of drive past, present and hypothetical and as applied to the endless variety of trades and services for which vessels must be adapted.

Before misleading anyone into further reading of this article let several premises be made clear.

1. This article attempts a dispassionate dealing with pure generalities and along commercial aspects rather than technical possibilities.

2. Because the intent is to blaze out a line of individual speculation no conclusions may be anticipated. This idea is so controlling that actual quantities are completely excluded, leaving to each reader the task of supplying from his own experience, or from accepted data, all quantities pertaining to existing forms of drive, while for hypothetical cases there may be entered any such fair approximations as may be obtainable or may be computed.

3. That to attempt to reach a reliable conclusion by such shortened methods as failure to assign quantities to this or that item is contrary to the underlying inception. This is much better satisfied by crude approximations than by disregarding such items and their effect.

4. There is no claim to novelty connected with this article or with the blank "balance sheet" which follows. The theme depends wholly upon refusal to accept, as conclusive, arguments which depend upon the consideration only of individual items to the exclusion of the ever present "constants" which cannot but result in what might be termed a "distorted perspective."

5. No attempt is made to justify the terms in which the items are couched. If they do not appeal to any individual reader, he is as free as the air to adopt those of his own coining. The "bottom line" of course will be affected, but after all it is his "bottom line"; and his results, alone, are concerned.

The only cautions deemed necessary are:

(a) Do not use the blank for a single power plant but for two or more, including one upon which the data is fairly accurate.

(b) Do not be too confident that a change in one item leaves all the others unaffected. Fill each out for each plant with due regard to the possible consequences of each item upon another.

(c) Do not attempt to compare two plants of too dissimilar size or characteristics.

(*d*) Eschew all terms of fuel per h.p.-hr whether it be i.h.p.-hr or b.h.p.-hr. If so presented to you, require that it be reduced to consumption per day under definite conditions or compute this for yourself.

Items	Plant X	Plant Y	Plant Z
Interest for given period on total cost of complete plant @ ....% per annum	$.....	$.....	$.....
Total repairs and replacements for power plant for above period.....	.....	.....	.....
Depreciation and deferred maintenance charges apportioned to above period	.....	.....	.....
Fuel expenditures for above period.....	.....	.....	.....
Lubricating oils for above period	.....	.....	.....
Engine-room attendance for above period.....	.....	.....	.....
Demurrage on ship for detentions in port or at sea due to plant trouble or fuel shortage, etc....	.....	.....	.....
Add			
Total gross expenditures	$	$	$
Extra cargo carried by reason of less weight of plant, fuel, water, etc., or by less volume of plant space, bunkers, tanks, etc., and credit for supplies eliminated..	.....	.....	.....
Deduct			
Net cost of operation...	$	$	$
Divided by revenue miles = cost per ship-mile....	$	$	$
Divided by ship's net-cargo tonnage = cost per ton-mile—BOTTOM LINE..	$	$	$

Each, to one's liking, may sub-divide these items, may include others or apply additional items of credit as may permit more readily securing the data from their records, or from their accounting office, and those who may so desire may very properly include items not strictly connected with the power plant operation but which may be affected thereby. The form and amount of credit, too, may take very different complexion if a vessel be engaged in service involving heavy cargoes of small bulk or bulky cargoes of relatively light weight. In the one instance reduced volume of "space occupied" is of little moment while reduction of weight of power plant and of fuel, fresh water, etc., may be of large importance. In the other instance the reverse may be true. Again, relief from the necessity of frequently requiring fuel or water, especially where such supplies are poor, or high in cost, may effect savings beyond the actual reduction of operating costs.

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Under these, and other, conditions of extremely wide limits of variation, no selection of drive is a matter of this or that advantageous characteristic. For every given combination of conditions, some one system of propulsion is best adapted and this one will not appear to disadvantage in such a line of comparison as that proposed, though one not nearly so well suited may appear better when discussion is limited to some particular feature of merit.

It cannot but be realized that objection may be found to the final reduction to terms of " ton-miles " or even to " ship-miles " but such objections may not loom so large if two matters be appreciated. The first of these is that this is to be considered only as a relative " figure of merit " into which all other items enter with their proper "weighting." The other is that the " period " may be chosen with a view to eliminating untoward conditions and need not be the same for any two of several plants included in the same comparison.

A further, and possibly more convincing, reason is that it affords, for true comparison, many elements of operating costs which may not be apparent from analyses dealing only with specific characteristics. As an example illustrative of this statement, consider the "bottom line" for two plants involving two Diesels, each requiring "n" pounds of a given fuel, per b.h.p.-hr., when each is operating under its full rated load at its own designated rotational speed. One is direct connected to its propeller shaft. The other drives an electric generator of 95 per cent efficiency furnishing current to an electric motor, which is also of 95 per cent efficiency, direct connected to a propeller shaft, wherein, to produce 1 h.p.-hr., there needs must be burned $\frac{n}{0.95 \times .95} = 1.12\ n$ pounds of fuel.

Assume, further, that the first engine's full load speed is the moderate one of 125 r.p.m. and, to make these revolutions, recourse must be had to a propeller wheel of but 50 per cent efficiency, whereas, the electric motor is guaranteed to be big enough to be capable of turning a propeller wheel of 70 per cent efficiency. Under these two very ordinary conditions, the equivalent of a horse-power-hour pull upon a " hypothetical tow " line will require in the case of the first plant $\frac{n}{0.50} = 2\ n$ pounds of fuel per hour; and, with the second, $\frac{n}{0.95 \times .95 \times .70} = 1.6\ n$ pounds of fuel per hour.

From these considerations, it develops, clearly enough, that instead of the second Diesel requiring to be of 12 per cent greater capacity than the first, it need be only 80 per cent of that capacity and that its consumption would be as much as 20 per cent less, but still there is information yet to be learned from the " bottom line "; the problem is not yet concluded.

To follow through, there must be learned the weight and cost necessary to the Diesel operating at an equally reliable rotational speed for driving a generator, 0.80 x 0.95=76 per cent the output of the first Diesel; plus the weight and the cost of this generator; together with the weight and the cost of the electric motor guaranteed to turn a propeller wheel of 70 per cent efficiency absorbing $0.80 \times 0.95 \times .95 = 0.722$ per cent of the first Diesel; together with the weight and the cost of the auxiliaries, controls, wiring, etc., between the second Diesel and its propeller shaft. This data will considerably affect the relative interest charges for the two plants under consideration, it will also affect their relative weights as it will the bunker requirements of each, the cargo credits of both and it may very likely affect differences in the items of Engine Room attendance.

Under such diversities of conditions as surround every problem of ship propulsion, it would be vain to propose any empirical rule which might not prove positively misleading. In consequence, the purpose of this article will have been achieved if it does no more than to emphasize the fact that what the owner must have is a fair conception of the price, under his conditions which he must pay, under one ledger account or another, reckoned in " Units of Pull " upon a hypothetical tow line in order that he may intelligently choose the one he deems he can best afford.

This information is not contained in a multiplicity of segregated statements which may likely confuse him and that cannot be but the poorest of business in the long run. Give him the " bottom line "!

Motor Passenger Liner for Brazil

Interesting Twin-Screw Diesel-Driven Vessel to Be Built in South America

IT is proposed by the well-known South American shipowning and shipbuilding firm of Companhia Nacional de Navegacao of Rio de Janeiro, which is said to be controlled by the Brazilian Government, to construct a 6,000 shaft horsepower Diesel-driven motor-liner with single-acting, two-cycle Sulzer oil-engines. Plans of the vessel shown on page 352 call for the carrying of 3,500 tons of cargo in addition to 300 passengers on three decks. She is designed as a twin-screw ship with 3,000 b.h.p. on each shaft, and will have a length of 383′ 6″ b.p., with 53′ 8″ breadth and 28′ 5″ moulded depth, and will be a fast ship. Accommodation is provided for 150 first class and 150 third class passengers. This enterprising concern already owns two motorships, one of 520 s.h.p. and the other of 1,040 s.h.p. with Sulzer engines.

Reduction-Geared Motorship "Muensterland"

One of the Hamburg-America Line's Diesel-Driven Freighters at New York—Six Duplicates to Be Built

THE first information to be published concerning the Hamburg-America Line's reduction-geared motorship HAVELLAND is to be found in the November, 1921, issue of this magazine and additional descriptive matter was published in MOTORSHIP for January, 1922. Recently the sister ship MUENSTERLAND visited New York and some data regarding this vessel is now available.

Like the HAVELLAND she was built by Blohm & Voss of Hamburg, for the Hamburg-America Line, and is powered by two 10-cylinder 20.866″ bore by 20.866″ stroke Augsburg four-cycle, trunk-piston type Diesel engines turning at 230 r.p.m. driving a propeller shaft thru reduction gears at 85 r.p.m., giving the vessel a loaded speed of 12 knots. This gives a ratio of 2.7 to 1. The entire weight of the machinery is only 250 tons. The engines were not designed especially for the reduction gears, but the reduction gears instead were adapted to the engines which were originally built for submarines.

The length of the engine-room is 72½′ which could have been considerably reduced if desired, as the overall length of the main engines is but 37′ 5″. Owing to the German Registration rules, advantage could not be taken of this space, so the builders preferred to give the benefit of the extra room to the engineers. In comparison with a sister motorship that has direct Diesel drive, a saving of about 330 tons and 6,000 cu. ft. has been made. If the German rules were altered, an additional saving of 18,000 cu. ft. could be made.

The leading dimensions of the MUENSTERLAND are as follows:

Displacement (loaded S.W.)	14,700 tons
Displacement (light S.W.)	4,600 tons
Deadweight capacity	10,100 tons
Net-cargo capacity on 26,000 m. voyage	8,335 tons
Fuel-capacity (double bottoms)	1,400 tons
Fresh water	220 tons
Cruising radius	90 days at 12-knots or 26,000 miles
Speed (loaded)	12 knots
Speed on maiden vge. (partially loaded)	11.12 knots
Trial speed	12.3 knots
Cubic capacity of holds	10,846 cu. meters
Power (indicated)	4,500 h.p.
Power (shaft)	3,300 h.p.
Daily fuel-consumption	15 tons
Daily lubr.-oil consumption	225 lbs.
Brake h.p. hour fuel-consumption	0.42 lb.
Weight of machinery	250 tons
Length of ship (O.A.)	465 ft.
Length of ship (B.P.)	450 ft.
Breadth (M.D.)	58 ft.
Depth (M.D.)	29 ft. 6½ in.
Draught (mean)	25 ft. 1 in.
Type of auxiliaries	electric
Classification	German Lloyd A1
Gross tonnage	6,314 tons
Net tonnage	3,804 tons
Passenger accommodation	12 first class
Date put in service	Jan. 20, 1922

Up to the present time the MUENSTERLAND has covered 55,000 miles—her regular route being from Hamburg to China. According to Julius Meyer, who represents the Hamburg-America Line in New York, six additional reduction-geared motorships are being built, but to carry more passengers, which would indicate that the reduction-gear oil engine drive is successful in operation.

To avoid the engine-room crew interfering with the gears, the casing is padlocked, the key being kept by the Chief-engineer—which is an excellent idea. Judging by an inspection of the gears thru the hand-covers the teeth are in excellent condition, bearing

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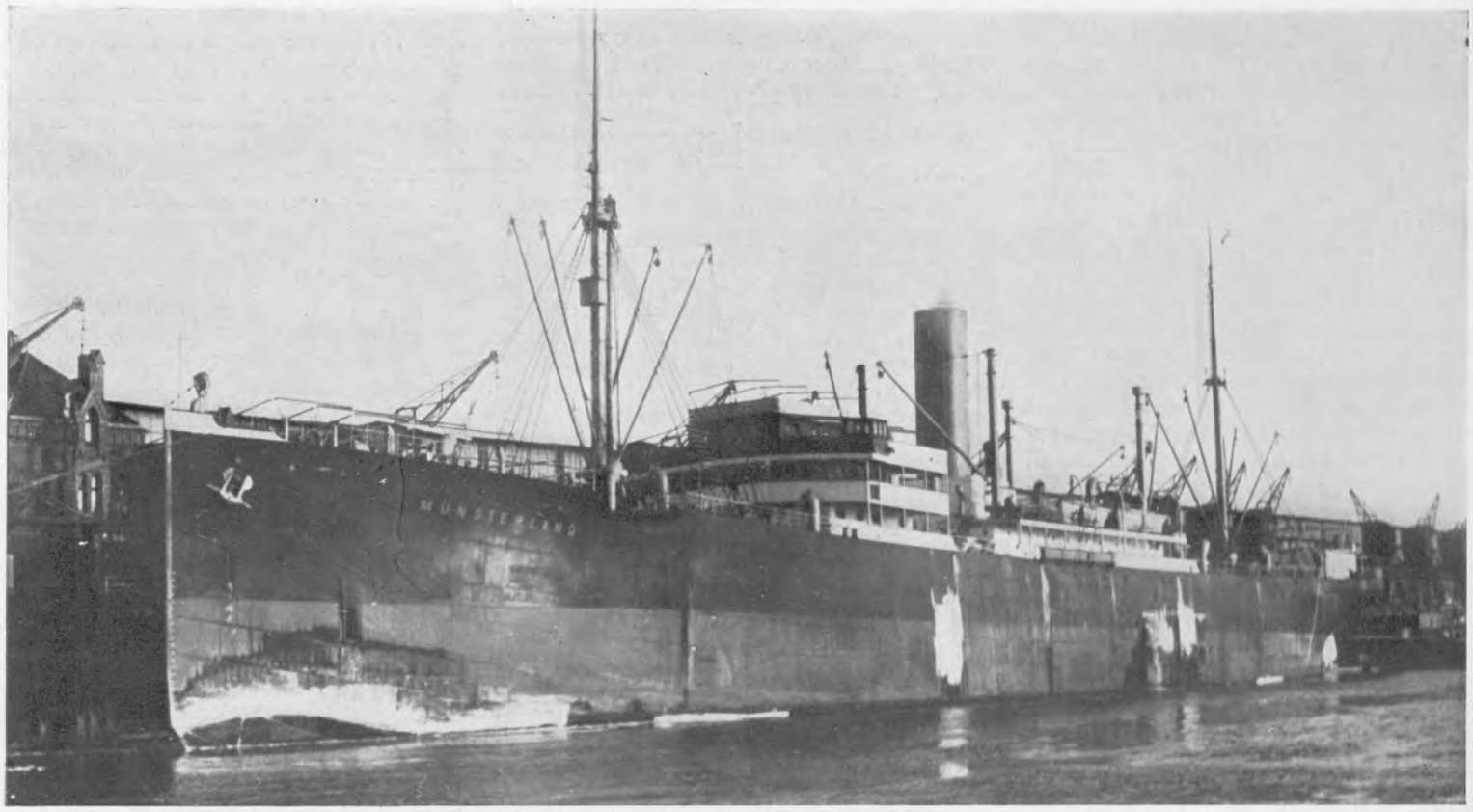
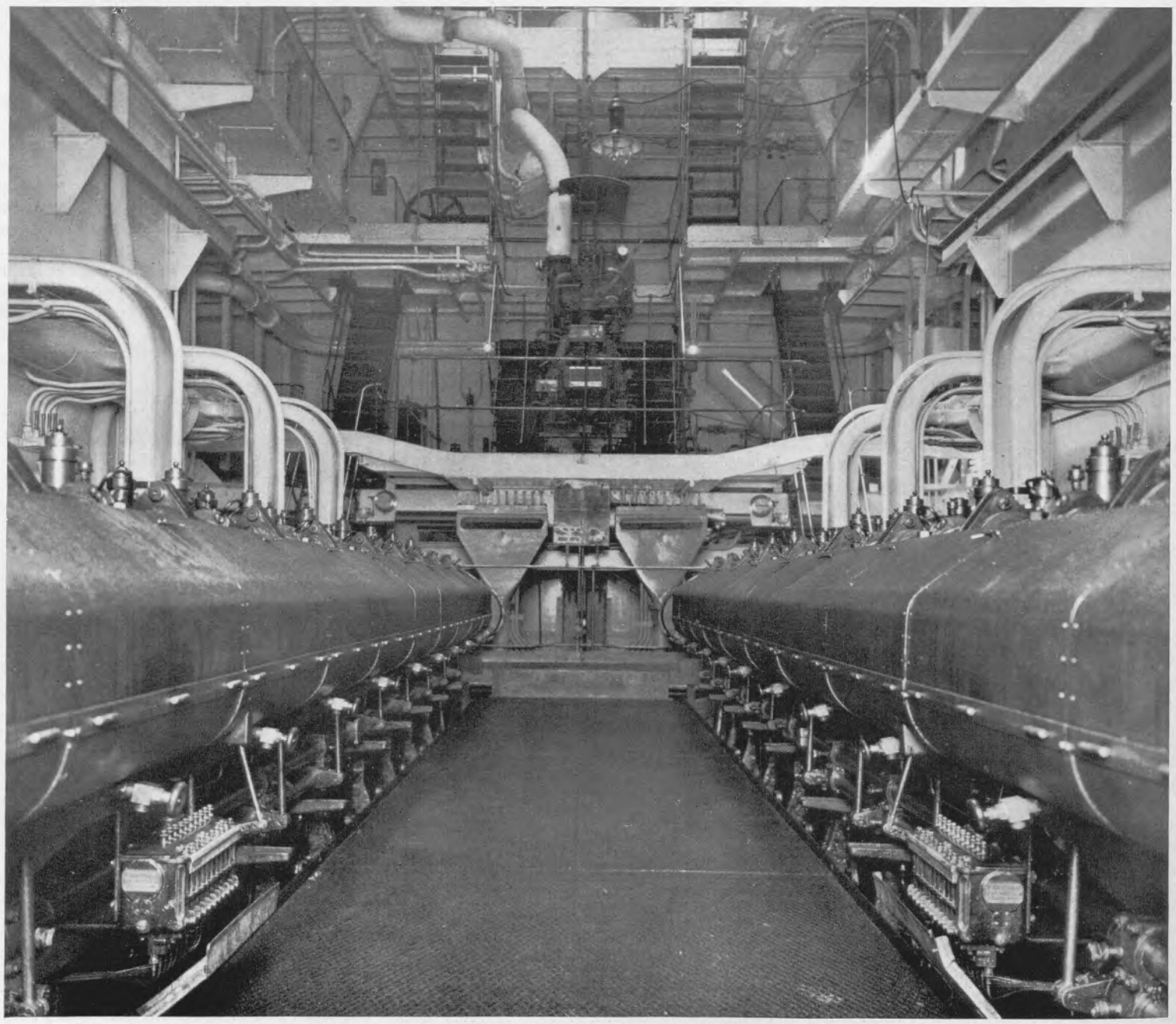


Hamburg-America Line's Diesel-engine reduction-gear driven motorship "Muensterland"



M. S. "Muensterland," upper platform of the engine-room showing the two 10-cylinder Augsburg high-speed Diesel engines

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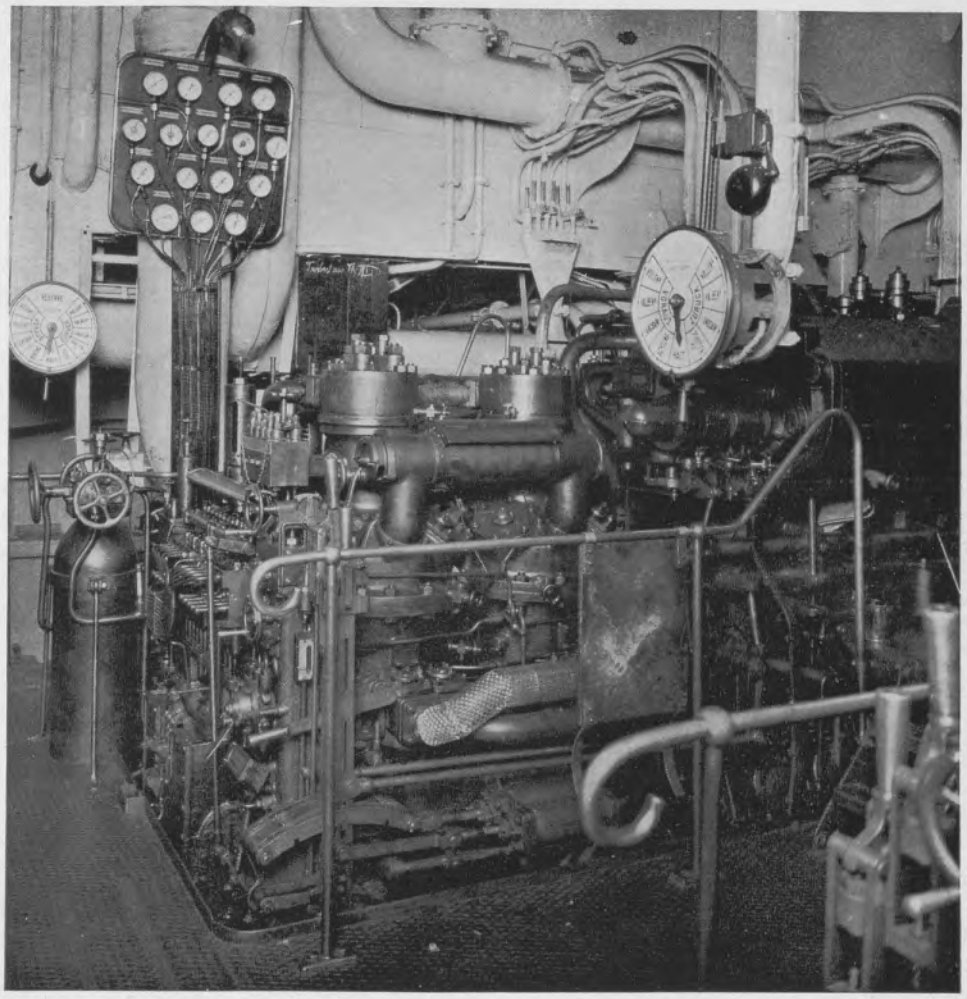
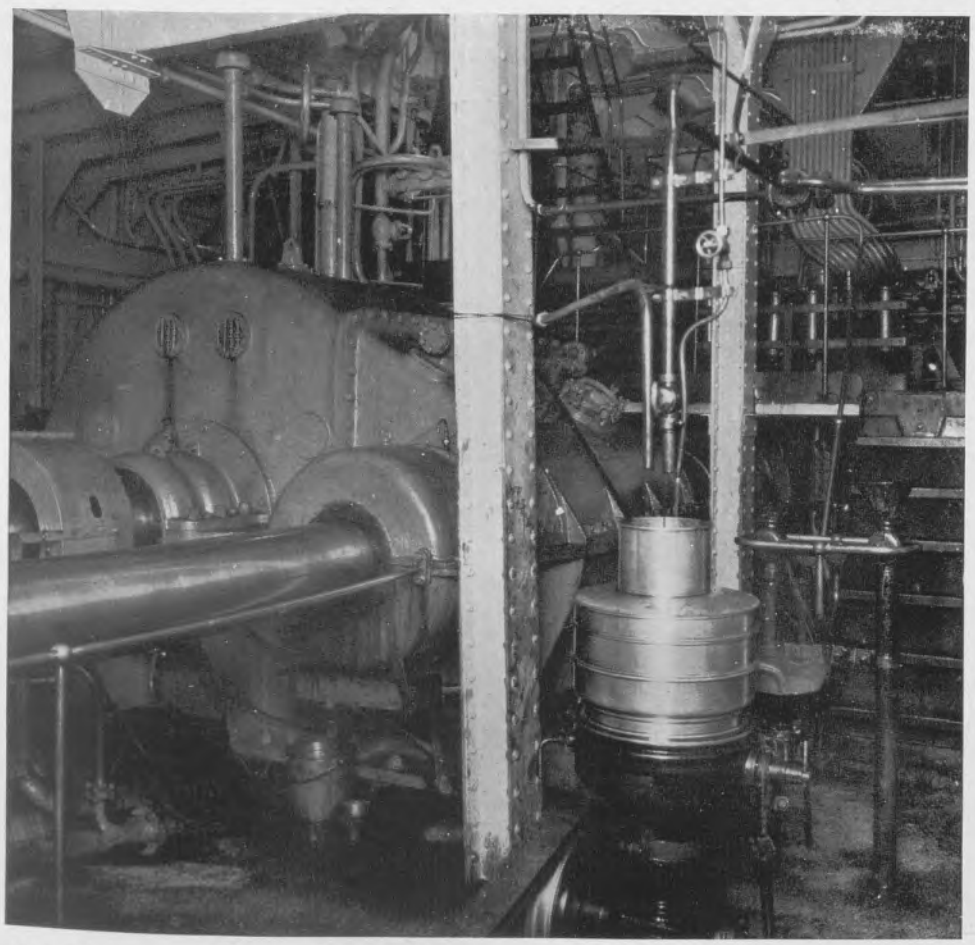
over their full surface. There were only a few pitmarks on the teeth which could not be noticed by anyone but the most critical. The gears have cast-iron spiders with forged steel rims which are forced on while hot. The gear case is of very solid construction with a Michell thrust-bearing aft and separate from the gear case. The pinions are integral with the shaft and are made of chrome vanadium steel. Running one's finger over the teeth shows that they are perfectly smooth with no signs of any undercut. The lubricant apparently bakes on the teeth where it stays. This oil is Vacuum D. T. E. heavy, and a pressure of about 10 pounds is maintained by gravity on the gears, the temperature being kept at between 100° and 120° F. when the vessel is in the tropics. Apparently the angle of the tooth is about 45° and there is almost one-half inch between the right-and left-hand helices.

As stated in our article on the HAVELLAND, the important question of the perfect operation of reduction gears between the engine and propeller was examined on a test stand, using gears of the actual size. In this connection, it became necessary to offset the negative turning moments, which occur with oil engines and are especially great in the neighborhood of the critical speed, in order to prevent excessive wear of the gear teeth. This end has been attained in the installation in question, not by the addition of separate elements, but by proper proportioning of the transmission shafting and a suitable distribution of revolving masses or balance weights.

During the trial trip, by means of special apparatus, the twisting moments in the shaft, ahead and astern of the reduction gears, were measured photographically; this measurement revealed a uniformity of twisting moment in the shaft on a par with that of a turbine installation. Special machines were purchased by Blohm & Voss for cutting the teeth which are cut close to 1/1000 mm. She has proved most economical. On the trial trip the consumption was measured at 0.3 pound per i.h.p. hour, while in actual practice the daily fuel-consumption is 15 tons with each engine developing about 1,650 brake h.p., or a total of nearly 3,300 shaft h.p. at the propeller. When in port the daily fuel-consumption is about 1,300 lbs. while the lubricating oil consumption at sea is 225 lbs. per day. The MUENSTERLAND was first placed in service on January 20, 1922.



M. S. "Muensterland," tandem air-compressor at the forward end of the starboard engine



M. S. "Muensterland," showing the reduction-gear drive, also a German lubricating-oil purifier in the foreground

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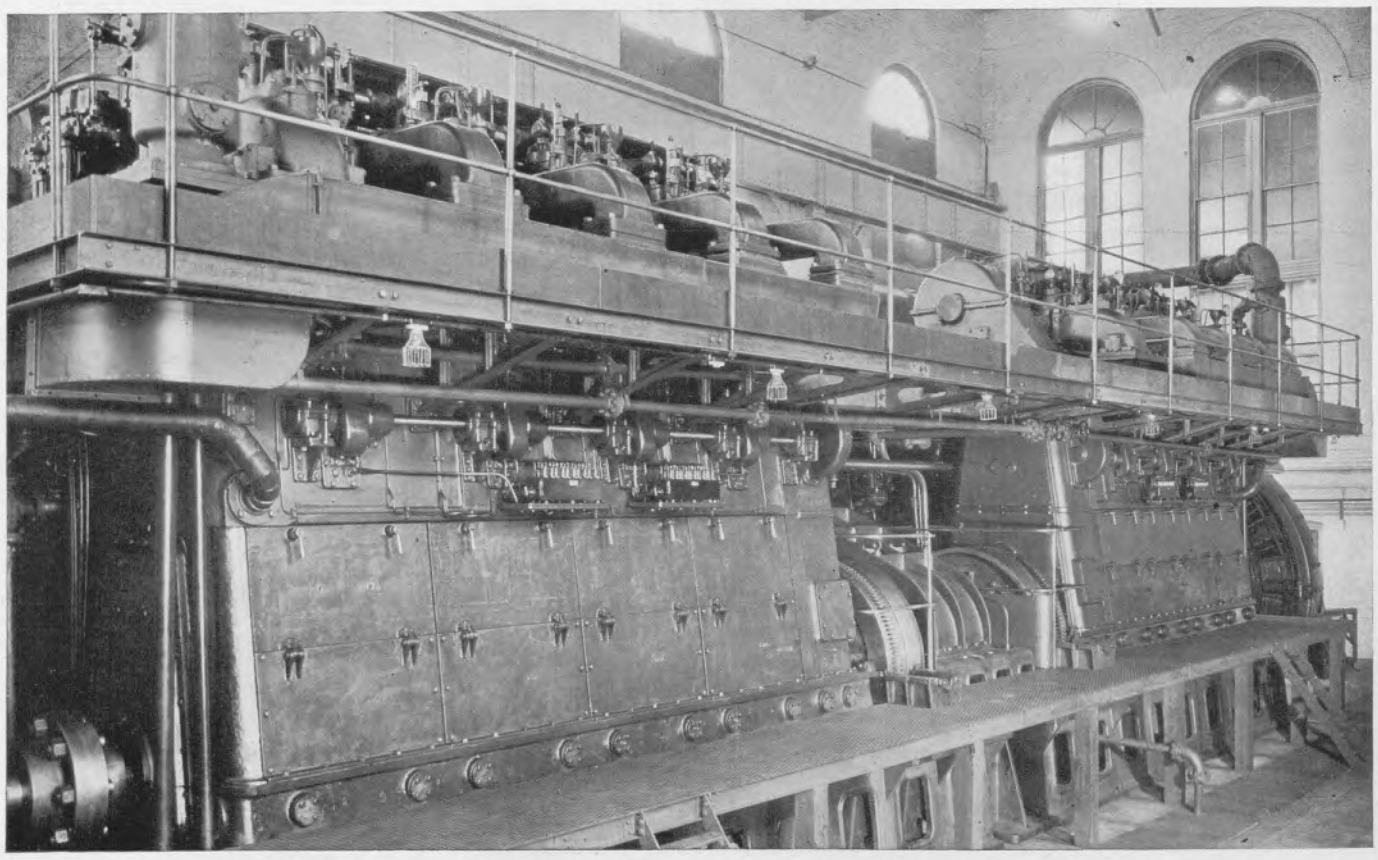
THE FALK SUPPLEMENT

ALL subscribers to MOTORSHIP receive with their copy this month what constitutes a novel, impressive and well thought-out method of introducing a notable departure in marine practice, and carries the initial announcement of the successful completion of a very big and difficult engineering task by The Falk Corporation, of Milwaukee, Wisconsin. This has taken the form of an artistic advertising Supplement that has been under preparation for many months, copies of which are being mailed simultaneously with the current number of this magazine, but of which it is not practical to make any distribution through the news-stands.

In this Supplement is portrayed a fully illustrated story of the tremendous engineering effort involved in the production of a quadruple airless-injection oil-engine unit with a special form of power transmission to a single propeller-shaft, the whole set forming an unusual combination of marine engineering ideas that already are being followed in Europe. The absorbingly interesting account of the numerous technical problems encountered, and of how by sheer concentrated application of American engineering skill and unstinted perseverance these were conquered one by one, must create a profound impression in shipping circles as well as cause not a little stir in the engineering profession. The particular task of the reduction-geared oil-engine drive was one at which nine firms out of ten might have failed to attain proper success. So the narration in almost minute detail of this great oil-engine development work—which alone amongst technical publications we have been permitted to watch closely for nearly three years—makes available to the engineering industry data that is usually retained for the private research archives of the firm which has made the investment.

Not only in the engine, but in the entire marine unit are incorporated many excellent features of sound engineering construction and design. One cannot do otherwise than express admiration of the resultant product, which is a credit to American engineering. Probably the fact of the design of the Falk power unit being different to what engineers are accustomed will bring forth a considerable amount of comment and even criticism, so space in our pages is available for technical discussions of constructive nature. It is, however, one of the instances where it may be necessary to see to believe. After the novelty of the system has worn off, the arrangement gradually grows on one and becomes quite appealing. Our own experience with this engine shows that in operation it is very silent and free from vibration, while the maneuvering is of such simplicity that a school boy can reverse all four engines simultaneously. During the entire year's running no pistons, cylinders or cylinder-heads have cracked, nor has a bearing gotten hot or run, the original white metal being still untouched. Doubtless The Falk Corporation feel very gratified with the results of their development work and that the huge financial investment has not been in vain. Credit from the engineering world is due them for the experiment made and its satisfactory outcome.

We feel honored that MOTORSHIP has been selected exclusively for the purpose of this Supplement by the directors of The Falk Corporation, whose decision—we understand—



The new 2,200 b.h.p. Falk geared oil-engine marine drive which is fully described and illustrated in a special supplement to this issue of "MOTORSHIP," and which has been mailed free to all our subscribers

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was largely influenced by reason of this magazine having done so much to bring home to the shipping interests the economy of oil-engine power, hence forms a fitting medium to place on permanent record the latest advances in this field. If we may be permitted, we say with a little pride that we do not think any other publication in the country has had sufficient experience in oil-engine development to have prepared and produced the material embodied therein in a similar manner.

Never before has any American company adopted such a progressive policy for the express purpose of introducing a new engineering product, and The Falk Corporation are to be congratulated for their enterprise, and for having laid their cards on the table for all to see. No doubt their bold method of super-publicity will set a splendid precedent which will have many followers. Meanwhile they doubtless will reap the benefit of their foresight. Every possible test has been made of the unit under land operating conditions. The individual engines as well as the combined engine-and-gear set have been subjected to far more severe treatment than they will receive under average conditions at sea, including daily running under the care of semi-mechanic shop helpers. Every expectation of the designers has been exceeded, and the only test left is that of regular trade operation in a sea-going merchant ship.

REDUCTION-GEAR DRIVE FOR MOTORSHIPS

SIMULTANEOUSLY with the announcement of the successful completion of The Falk Corporation's merchant-ship reduction-geared oil-engine drive arrives the information from England that there have already been laid-down at Harland & Wolff's Belfast yard two new motor-liners of 17,000 tons displacement each, which are to have Harland-Burmeister & Wain high-powered Diesel engines in conjunction with reduction gears with an aggregate of 9,560 shaft horsepower, or sufficient to give the vessels a speed of between 17 and 18 knots. If this is the case it would tend to furnish strong support to the plans followed by American engineers as in the Falk installation, particularly as it is reported that the German engineers are also developing a reduction geared oil-engine drive for a passenger liner for the North German Lloyd, and that the two German freighters with Diesel reduction-gear drive have been successful to date and six more are to be built for the Hamburg-American Line.

On the other hand, it is our understanding that Burmeister & Wain themselves have not been very partial towards reduction-geared drive with oil-engines. Possibly Harland & Wolff made their decision regarding the machinery of these two big liners prior to the successful completion of the final tests of the Burmeister & Wain four-cycle double-acting Diesel engine, of which a pair of 6,500 shaft h.p. engines are now being built for the passenger motor-liner of the Swedish-American Line, and which they are prepared to build up to 9,000 shaft h.p. Quite possibly also they were influenced in their decision by considerations of shop production costs. In their Glasgow plant they have developed shop production methods to a degree which has been pronounced by one very well-known American shipbuilding executive to be on a par with the best practice in this country and to some extent even a little in advance of it. The Harland & Wolff firm, therefore, would probably be reluctant to put another type of engine into their shops, so long as they can take care of orders beyond the power of their standard sets by doubling-up on a geared drive. It is proposed to use four Harland B. & W. standard eight-cylinder, four-cycle type Diesel engines of 3,200 i.h.p. apiece; each pair being coupled by means of gearing to the twin propeller shafts. With this arrangement it will be possible to develop 4,800 shaft h.p. at each of the propellers, or a total shaft h.p. of 9,600. These two new motorships will be of about 17,000 tons displacement each. Because of these new orders we repeat the table of large Diesel-driven ships on order that was published in our April issue, making these additions as well as some big motorships previously ordered and now building, bringing the total to 20 ships aggregating 288,120 tons, 125,860 shaft h.p., with out counting almost one hundred smaller motorships aggregating about 750,000 tons and 200,000 h.p. which are also now under construction or being converted from steam drive. This means that there is a total of over one million tons of motorships building to-day.

YOU CAN'T GET AWAY FROM IT!

OIL in large quantities is being moved from the Pacific Coast to the Atlantic Coast via the Panama Canal. The average steam tanker consumes about one barrel of oil for every twelve transported. If these tankers were Diesel-driven only one barrel would be burned for every thirty-five shipped. No oil company can dispute this! Yet the wicked waste of valuable fuel under boilers is tolerated in the face of a fast dwindling domestic supply. This shortage must be prevented and America must protect future generations by conserving oil now! The responsibility of helping to conserve the supplies rests equally upon all oil users, but those who, for profit, promote its wider use have the added responsibility of disseminating the call for prevention of waste. How long will the policy of waste be continued?

LARGE DIESEL-DRIVEN MOTORSHIPS ON ORDER

(Revised)

Owners	*Type of Ship*	*Tonnage of Ship*	*Shaft Horsepower*	*No. of Screws*	*Speed*	*Make of Engine*	*Type of Engine*
Swedish American Line	Passenger Liner	17,000 gross	13,500	2	17 knots	Burmeister & Wain	4-cycle
Union Steamship Co	Passenger Liner	22,000 displ.	13,000	4	17 knots	Fairfield-Sulzer	2-cycle
Not Given	Passenger Liner	17,000 displ.	9,600*	2	17-18 knots	Harland-B. & W.	4-cycle
Not Given	Passenger Liner	17,000 displ.	9,600*	2	17-18 knots	Harland-B. & W.	4-cycle
Rotterdam Lloyd	Passenger Liner	12,000 gross	7,000	2	15 knots	Schelde-Sulzer	2-cycle
Hamburg-South America Line	Passenger Liner	12,000 gross	6,000	2	13½ knots	Blohm & Voss	4-cycle
Elder Dempster Co	Passenger Liner	9,000 gross	5,250	2	12¾ knots	Harland-B. & W.	4-cycle
Not Given	Freighter	14,000 d.w.c.	5,250	2	12½ knots	Harland-B. & W.	4-cycle
Axel Broström	Ore Carrier	22,000 d.w.c.	5,000	2	11 knots	Burmeister & Wain	4-cycle
Axel Broström	Ore Carrier	22,000 d.w.c.	5,000	2	11 knots	Burmeister & Wain	4-cycle
North German Lloyd	Passenger Liner	9,450 gross	5,000*	2	12 knots	Vulcan	4-cycle
German American Petroleum	Tanker	17,000 d.w.c.	5,000	2	11½ knots	Howaldtswerke-Sulzer	2-cycle
Royal Mail S. P. Co	Freighter	14,000 d.w.c.	5,000	2	12½ knots	Harland-B. & W.	4-cycle
Holland America Line	Freighter	14,000 d.w.c.	5,000	2	12½ knots	Harland-B. & W.	4-cycle
Ocean S. S. Co	Freighter	12,000 d.w.c.	5,000	2	13 knots	Burmeister & Wain	4-cycle
Hamburg-South America Line	Passenger-Cargo	12,000 d.w.c.	5,000	2	13 knots	Sulzer	2-cycle
British India S. N. Co	Passenger Liner	10,670 d.w.c.	4,660	2	13 knots	North British	4-cycle
German American Petroleum	Tanker	15,000 d.w.c.	4,000	2	11 knots	Sulzer	2-cycle
Nippon Yusen Kaisha	Passenger-Cargo	10,000 d.w.c.	4,000	2	12 knots	Sulzer	2-cycle
Nippon Yusen Kaisha	Passenger-Cargo	10,000 d.w.c.	4,000	2	12 knots	Burmeister & Wain	4-cycle
		288,120 tons	125,860				

*Reduction gear drive.

The 6,000 shaft h.p. Sulzer engined motorship for the Brazilian Government's line not included in list as order not confirmed.

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Canadian Pacific R.R. Ferry "Motor Princess"

First Vessel in Their Fleet to Be Propelled by Diesel-Engines — Twin McIntosh & Seymour Units Fitted

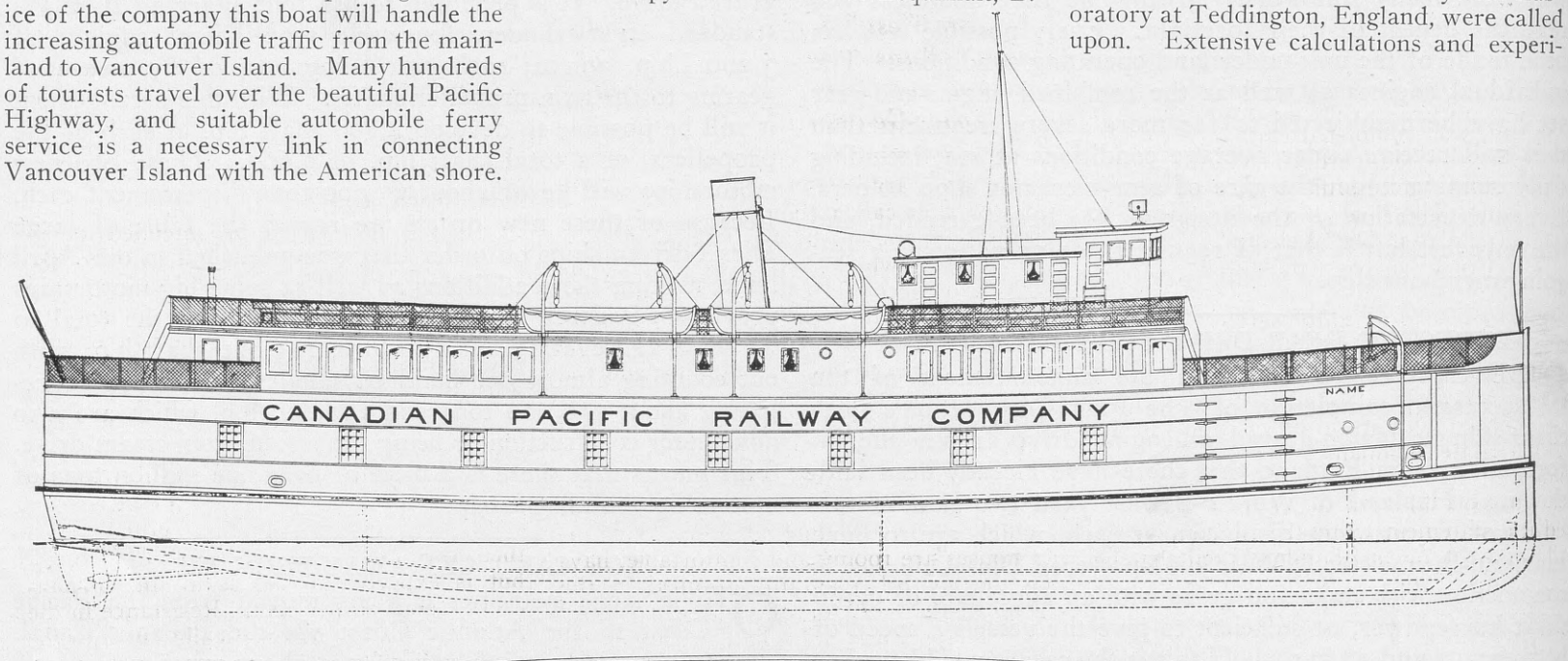
CHARACTERISTIC of the progressive policy which has ever distinguished the operation of this great transcontinental transportation system is the adoption of Diesel-power for its latest boat. After many years of operation of steam-propelled craft, both large and small, at ports on the route of its great railway system, the C. P. R. is now installing McIntosh & Seymour Diesel-engines in its new ferry as previously indicated in our pages. This boat will be placed in service this month between Sidney, Vancouver Island and Bellingham, Washington.

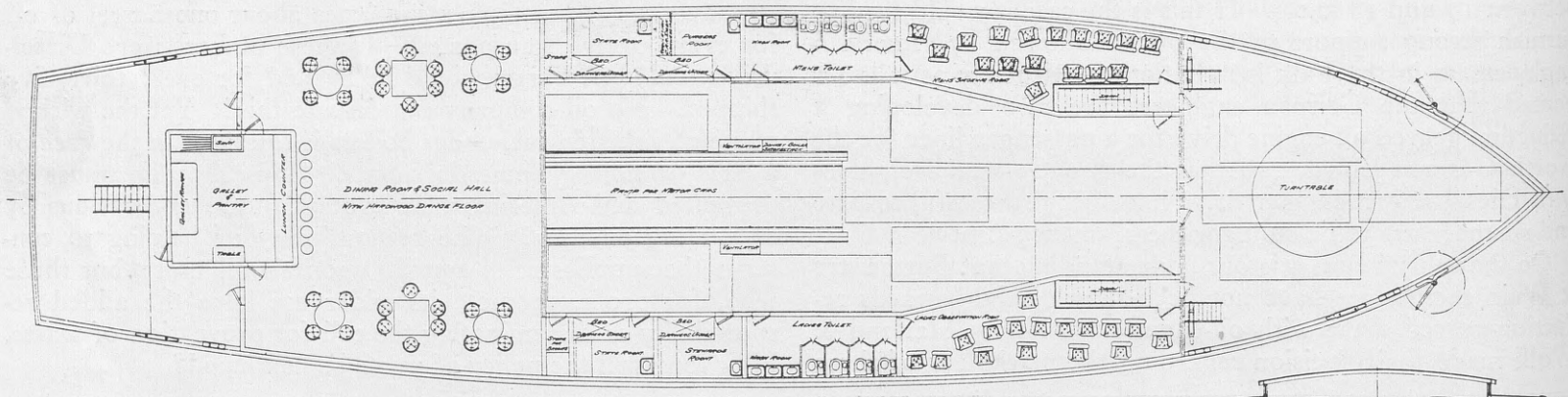
In addition to the usual passenger service of the company this boat will handle the increasing automobile traffic from the mainland to Vancouver Island. Many hundreds of tourists travel over the beautiful Pacific Highway, and suitable automobile ferry service is a necessary link in connecting Vancouver Island with the American shore.

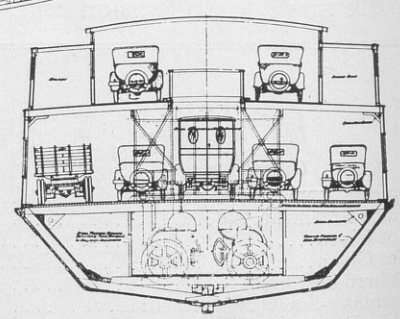
To accommodate this class of travel the Canadian Pacific Railway decided last Fall to provide a ferry which should be particularly adapted to the work.

Capt. J. W. Troup, Manager of the British Columbia Coast Steamship Service of the railway, conceived the idea of operating such a vessel and went about the work of design in a most thorough manner. In co-operation with the builders, Yarrows, Ltd., whose shipyard is located at Esquimalt, B. C., and who are associated with the firm of Yarrow & Co., of Glasgow, Scotland, Capt. Troup drew up designs of the ferry. As good speed and large carrying capacity were essential features to which the owners attached special importance, considerable difficulty was experienced in the design.

With the carrying capacity of 45 automobiles specified, the minimum breadth was settled and a form of hull determined upon, which would permit a speed of 13-14 knots with minimum power and maximum efficiency. In arriving at this form and horsepower the services of the large William Froude tank at the National Physical Laboratory at Teddington, England, were called upon. Extensive calculations and experi-

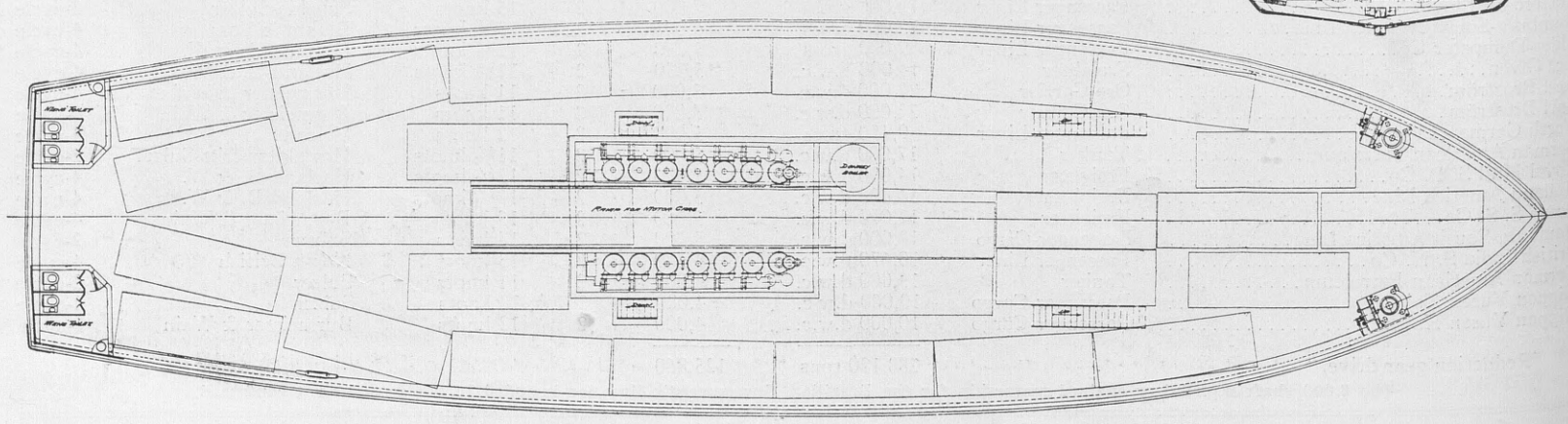






C. P. R. Diesel-driven ferry "Motor Princess," powered with twin 600 shaft h.p. McIntosh & Seymour oil engines

GENERAL ARRANGEMENT PLANS



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ments resulted in the form of hull shown in the accompanying illustrations. The MOTOR PRINCESS has the following dimensions:

Length (O.A.)	170'0"
Breadth	42'8"
Depth	11'5"
Power	1,200 shaft h.p.
Speed	14 knots
Capacity	45 automobiles

This most attractive ferry is scheduled to be placed in service soon after her delivery by the builders on May 15th, and will resemble more nearly the usual type of passenger craft than the typical passenger-automobile ferry. In addition to the modified V-bottom form of hull she embodies other features worthy of note. She will carry autos on the upper as well as on the main deck, a ramp being provided on which the cars can climb under their own power from one deck to the other, eliminating any necessity for an elevator or unsightly posts and platforms. In loading and discharging the arrangement is thus quite convenient, making it possible to handle a large number of cars quickly and safely.

While making the three-hour trip, passengers are provided with very comfortable salons, smoking rooms and dining room. The latter is to have a maple dance floor. Hot and cold water, electric lights, heat and fire service are provided and large observation windows are shown throughout.

Two six-cylinder 600 shaft h.p. McIntosh & Seymour Diesel-engines are installed, the cylinders extending up into a casing on the main deck on either side of the ramp. A donkey-boiler provides steam for heating. Propellers and rudder are fitted at one end only of the boat. Her cost is reported to be $300,000.

Three Golden Gate Diesel-Electric Ferries

"Golden West," Sister to the "Golden Gate," Runs Trials. Will Be Followed by Third Pacific Werkspoor-General Electric Ship

THE Diesel-driven ferry GOLDEN WEST, second of what promises to be a considerable fleet of Diesel-electric boats owned by the Golden Gate Ferry company, was completed early in April by the Robertson Shipyard, of Alameda, California, and successful acceptance trials were run. The boat is a sister, almost a twin, of the first Diesel-electric boat built on San Francisco bay—the GOLDEN GATE, which is giving satisfactory service in the San Francisco-Sausalito service for the same owners.

The GOLDEN GATE has shown such satisfactory service and shown such economies as compared with steam-driven boats in the Golden Gate company's service, even as compared to smaller boats, that Aven J. Hanford, president of the company, authorized the statement while the GOLDEN WEST still was making her builders' trial that he soon would order a third boat of similar type to be called the GOLDEN BEAR.

The GOLDEN WEST is a wooden vessel of 220 feet overall length and 214 feet on the waterline. Her beam is 60 feet overall, the hull proper being 44 feet. Her moulded depth is 17 feet six inches and her draft, light, is 10 feet six inches. Loaded she is expected to draw about seven inches more. Her gross tonnage is 600, approximately, but this gives no idea of the size of the boat, as the entire lower deck, except a narrow enclosure in the center containing pumps, engine-room well and small compartments for conveniences, is open.

She will carry between 75 and 80 automobiles, and can accommodate more than 500 passengers, chiefly on her upper deck, nearly all of which is enclosed against the weather on account of the windy conditions prevailing on the San Francisco-Sausalito run, where she will be used. This cabin contains a lunch room and galley and the other accomodations for passengers usual on ferryboats in that section.

There is a pilot house forward and another one aft, virtual duplicates as to arrangement and fittings. Both are glazed all around and have sliding windows. The pilot houses are roomy and comfortable, having the control apparatus grouped in the center of the front and the emergency hand steering apparatus immediately behind this with an ample free space at the rear.

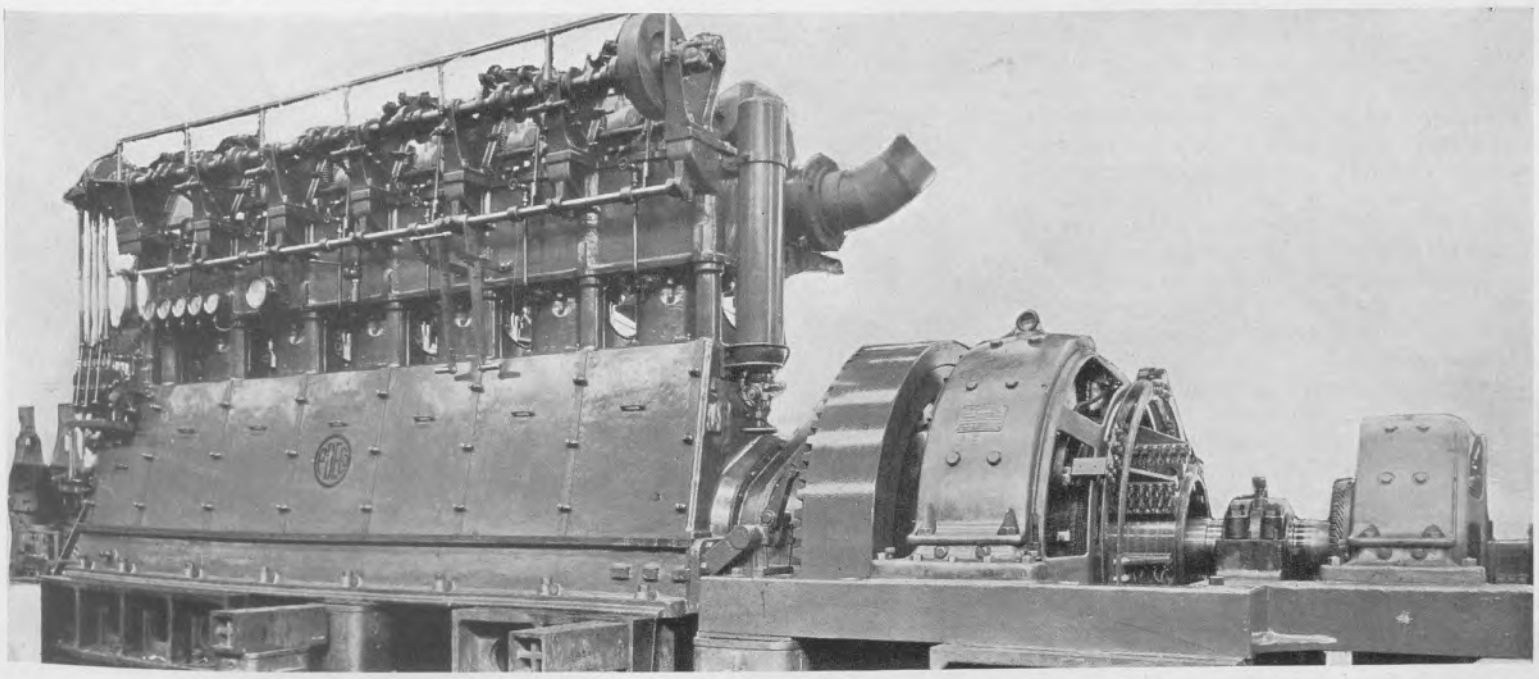
The engine-room, which occupies the center of the boat below decks ,also is commodious and has large spaces outside the main stanchions, outboard of the engines, which can be used for storing engine-room supplies.

The vessel has two Pacific-Werkspoor engines, each of six cylinders and 525 brake horsepower. They are non-reversible and turn outboard. On the crankshafts of these are mounted two 360 kilowatt 250 v. direct current generators and the two 115 v. direct current exciters. Engine, generator and exciter not only are mounted on the same shaft but occupy the same bedplate, making a very rigid and compact unit, operating at 225 revolutions per minute.

At each end of the engine-room is mounted a driving motor, intended to operate at a speed varying from 145 to 180 revolutions per minute. The motors take current at 500 volts from the generators, connected in series, and are themselves connected in series, which aids in the automatic adjustment of loads between them. All this electrical equipment is of General Electric construction.

Both driving motors and propellers run all the time the vessel is in operation, but at different rates. The exact difference in their revolutions has not been determined, but is expected to be, as in the GOLDEN GATE, about 20 per cent. Resistance in the control circuit is automatically cut into the field of the after motor to increase its speed when the controls are thrown over for forward movement, so that the forward propeller turns at as nearly as may be a speed only sufficient to overcome its own resistance, the after propeller taking the burden of driving the boat.

Proponents of this form of drive assert that it shows such an economy, on account of the forward propeller not throwing back a column of water against the oncoming hull as is the case in vessels where both pro-



One of the twin 525 b.h.p. Pacific Werkspoor-General Electric generating units of the "Golden West"

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pellers forward and aft are mounted on the same shaft, as to compensate entirely for the loss of energy in the electric drive, as compared with direct drive. If either motor should be disabled, the other would pick up the entire burden of driving the ship, regardless of whether she was going ahead or astern. Similarly, in emergency, either engine can drive her, though at reduced speed.

Beside the main exciters, there also is an auxiliary exciter, above the main deck level, which can be connected to the bilge and fire pump apparatus. All the auxiliaries on the vessel are motor driven except this exciter, which is run by a four-cylinder Sterling gasoline engine, producing current at 120 volts. Also above the main deck level are two Kinney pumps which can be connected either as bilge or fire pumps. Each engine also carries a bilge pump, circulating water pump, fuel-oil transfer pump, lubricating-oil pump and air compressor. The engines have force-feed lubrication throughout, with Manzel sight-feed lubricators to the detachable cylinder skirts, connected to lubricate both inboard and outboard sides.

A main bilge pump, supplied by the Pacific Diesel Engine Works and motor operated, is located on a platform built out from the engine room, beyond the main stanchions near the boat's skin. In this same space on each side of the boat are located the fuel-oil storage tanks, which are cylindrical and of steel, and the daily service tanks, also steel cylinders. The service tanks are of ten barrels capacity each. In the engine-room, forward of the engines, are a Rix auxiliary air-compressor, delivering air at 250 pounds for starting, a Rix booster to raise this to 1,000 pounds pressure for injection, a De Laval purifier for cleaning used lubrication oil, beside the necessary air and oil tanks.

The exhaust gases, a considerable advance in utilizing the heat of which is being made in recent Diesel vessels, is used in this case to heat air which is blown into the cabin, thus furnishing heat and ventilation at the same time. A motor-driven blower takes air from outside the boat, drives it through a shell surrounding the muffling apparatus, located in the short funnel above the upper deck, and delivers it through metal ducts at convenient points in the cabin.

The GOLDEN WEST'S propellers are a Hyde Windlass Company product, bronze, three-bladed of eight feet diameter and nine feet pitch, and drove her, on her builders' trials, at nearly 14 knots. This is slightly over expectations, she having been designed to give a speed of about 13½ knots, or sufficient to make her run across the Golden Gate in 18 minutes, with adequate margin for ordinary delays. This speed in part is due to the cleanness of her lines, the boat leaving an unusually smooth wake. Her keel was laid October 6, 1922, and she was finished in approximately six months.

An unusual feature of the GOLDEN WEST is that her propellers, tail-shafts and fittings are interchangeable with those of the GOLDEN GATE, but the boat herself is not quite a counterpart of the earlier craft. Her beam is slightly greater and her tail-shafts are four inches higher than those of the former boat. At the same time, her engine shaft lines are set slightly lower.

The control, as in the former boat, is on the Ward-Leonard system. That is, the speed and direction of the vessel's movement is controlled by varying the amount and direction of the excitation current in the generators. The main control apparatus is in the pilot houses, so that the navigating officer controls both helm and power, but there also is a complete control set in engine-room for emergency use. The large rheostats of the main controls are located in rooms just below the pilot houses which also shelter the driving motors, indicating apparatus and windlass drums of the electric steering gear. Both the electric steering-gear and the hand gear were supplied by the Allan Cunningham company of Seattle; the control apparatus is from the General Electric company.

For communication between pilot houses and engine-room, should it ever be necessary to have the engine-room take over control of the propulsion, there are two sets of Cory telegraphs of standard type as used in steam vessels. These telegraphs, the readily accessible hand steering apparatus, which can be put into use or retired from use in a second or two, and the auxiliary engine and fire and bilge pumps above the main deck level, are safety devices installed as added precautions.

The wiring system of the ship is elaborate. Either main exciter is sufficiently large for the needs of the two generators and all the lights, or of the pumps and blower, and all necessary lights. The auxiliary exciter unit is large enough to take care of both generators, or of one generator and necessary lights and fire or bilge pumps. It also can operate all bilge pumps. Should any generator or exciter or driving motor break down or be stopped by fouling of the propeller, it can be thrown out and the circuits left intact, except that in the case of a broken down generator the normal driving voltage could not be maintained. Altogether, the boat is a compact, thoroughly modern craft of a size, which the officers of the company believe ideally suited for the traffic to be borne and the working conditions to be met.

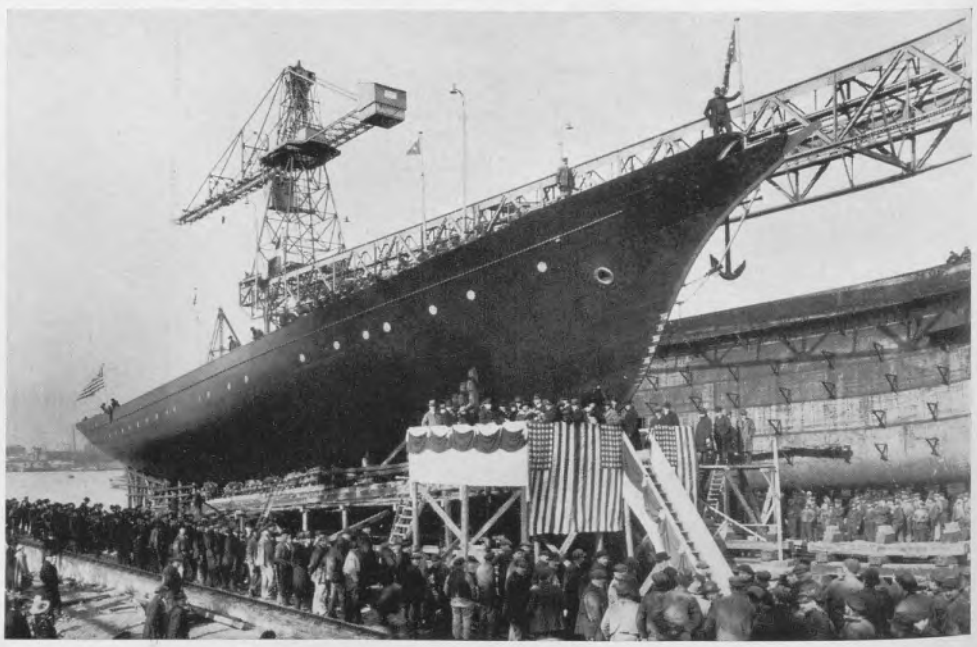
MORE DATA ON THE "TITANIA" AND "TIRADENTES"

In addition to our recent references to the new Deutsche Werft built motorships, TIRADENTES and TITANIA, for Wilhelm Wilhelmsen & Co., of Tonsberg, Norway, we are, after inspection of these ships, enabled to publish further data. As will be remembered, they are 400′ long, 50′ breadth, have a deadweight capacity of 9,000 tons, and are equipped with two six-cylinder, single-acting, direct-reversible Burmeister & Wain Diesel-engines each developing 1,550 indicated h.p. at 110 r.p.m.

The daily consumption of lubricating-oil for 24 hours is 13.5 gallons while the main engines only require 10.5 tons of 26 degrees Beaumé fuel-oil at 11.5 knots loaded speed. In addition to the main-engines there are installed three 115 h.p. Diesel auxiliary engines direct connected to electric generators which furnish current for all engine-room auxiliaries, ten deck winches, steering-gear and anchor windlass.

The engine-room auxiliaries comprise two lubricating-oil pumps driven by 12 h.p. motors, two 3-plunger sanitary and bilge-pumps driven by 13 h.p. motors, one fuel-transfer pump driven by 12 h.p. motor, two centrifugal cooling-water pumps driven by 12 h.p. motors, one maneuvering air-compressor with 90 h.p. motor, one small steam-driven emergency air-compressor, two ice-machines driven by 45 h.p. motors and two ventilating blowers driven by 25 h.p. motors. No. 3 hold is fitted for refrigerated cargo.

On both ships the engine-room crew consists of four engineers, one electrician and four oilers. On the TITANIA the experiment is being made of placing all electric winch resistors and main-contactor controls in the engine-room, being operated from deck by low voltage current control situated in a small box beside the winch. This plan provides a neat arrangement, but quite complicated, and we understand that it has not been entirely satisfactory inasmuch as the contactors in the engine-room draw heavy arcs, detrimental to the apparatus. On the TIRADENTES resistors and controls are located in a house at the base of each mast.



Launching E. F. Hutton's new Diesel auxiliary-yacht "Hussar" at the Burmeister & Wain yard, Copenhagen, Denmark, on March 15th

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First Sea-Going Diesel-Electric Tanker

"Standard Service," a Single-Screw Pacific Werkspoor-General Electric Propelled Vessel Just Placed in Service by the Standard Oil Co. of California

FOR many classes of vessels there can be no question but that Diesel-electric drive is exceedingly efficient and economical, particularly for ferries, fireboats, dredges and canal boats, and now its use is being extended to new freighters and tankers in which its performance will be watched with much interest. Its application to a bulk-oil carrier has just been carried out by the Standard Oil Co. of California in their new tanker STANDARD SERVICE.

Sea trials of the STANDARD SERVICE were completed off San Francisco on April 2nd, and have been pronounced eminently successful by both the builders and the owners. The normal speed of the propeller is 130 r.p.m., but during the builder's trial, it was operated at about 145 revs., and the load was less than 1,000 amperes, whereas full load rating on the motors is 1,065 amperes.

During the owners' trial, the craft was well loaded. Readings taken on four different occasions when the control was thrown from "full-speed ahead" to "full-speed astern" showed that at no time did the load go above 1,000 amperes. The change from full speed ahead to reverse took from ten to twelve seconds. During the reversal all vibration was eliminated, and unless one were observing the instruments he would have no indication of what was taking place on the propelling equipment. One of the directors of the Standard Oil Company, who was steering the boat with one hand and operating the controller with the other, was asked to throw the controller from full-speed ahead to full-speed astern and was amazed at both the simplicity and perfect control.

So satisfied were the directors of the Standard Oil Company with the results of the trials of the Diesel-electric tanker STANDARD SERVICE that they at once ordered a second pair of 400 b.h.p. Pacific-Werkspoor engines and General Electric drive for a duplicate tanker.

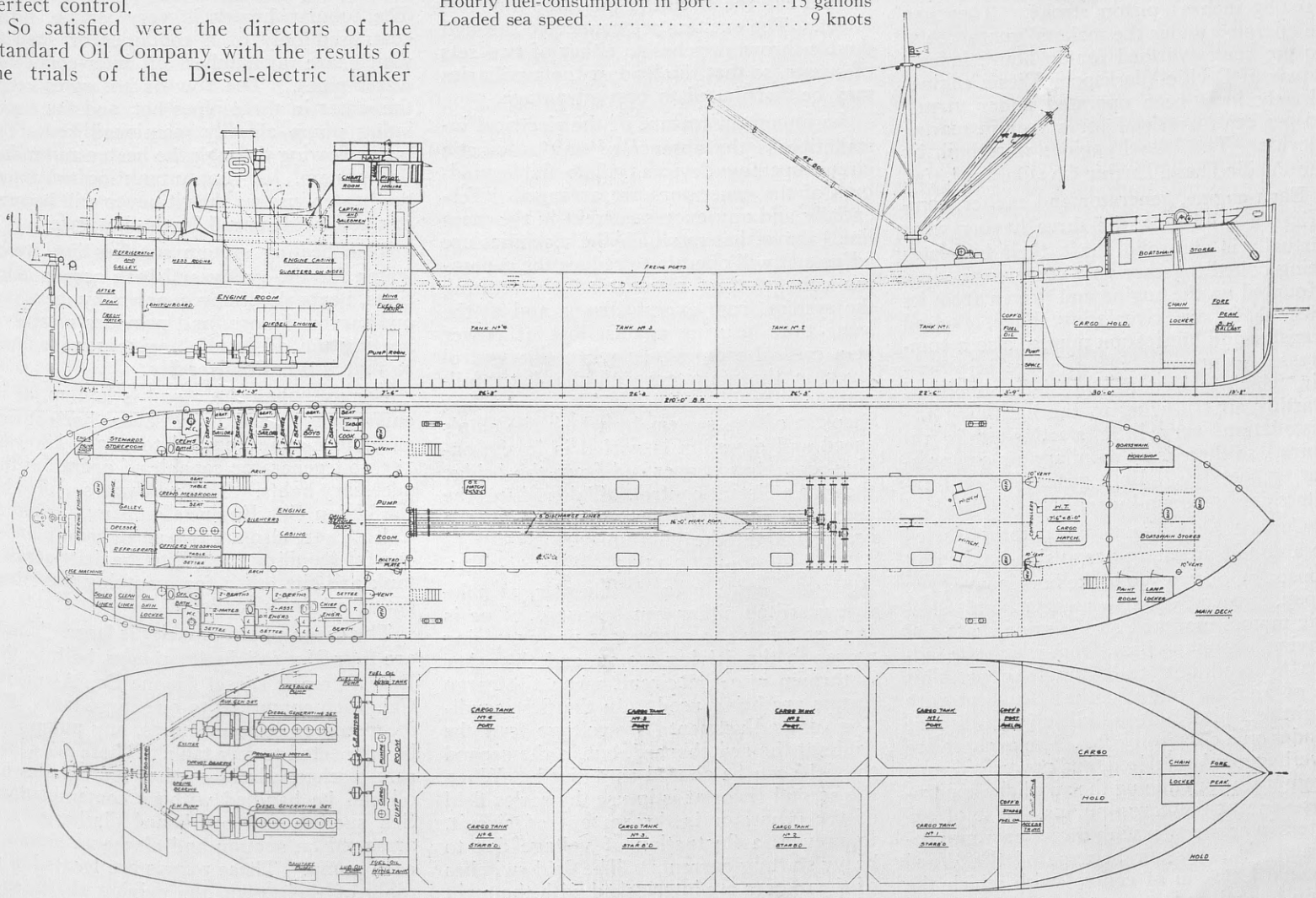
The STANDARD SERVICE embodies a number of pioneer steps. The vessel is a single, compact and self-contained unit, capable of caring for all her own needs, because she will be able to employ her own cargo-pumps which are electrically operated, whenever she is alongside the oil pier, whereas tankers with steam pumps often are required to take their steam from the shore, no fires being permitted aboard at some ports. She is expected to display several economies through elimination of certain auxiliaries, utilization of electric motor-driven cargo pumps, and employment of electric machinery throughout, all of which were made possible by the design of her propulsion machinery. There are two main engines, but only one propeller.

The following are the principal dimensions of the STANDARD SERVICE:

Loaded displacement	2,725 tons
Cargo-tank capacity	12,400 barrels
Dry cargo capacity	225 tons
Fuel-capacity	83½ tons
Deadweight capacity	1,875 tons
Cruising radius	24 days
Daily fuel-consumption at sea	3½ tons
Hourly fuel-consumption in port	15 gallons
Loaded sea speed	9 knots
Daily fuel cost (at $1.50 per barrel)	$35.75
Power at propeller	600 shaft h.p.
Power of two main engines together	800 brake h.p.
Propeller speed	130 r.p.m.
Engine speed	265 r.p.m.
Make of oil-engines	Pacific-Werkspoor
Make of electric transmission	General Electric
Engine cyl. bore and stroke	13.188" by 19.685"
Propeller	9' diam. by 8' pitch
Block coefficient of hull	0.76
Length of vessel	210'0"
Breadth	40'0"
Depth	16'6"
Mean loaded draft	15'0"
Builders of hull	Bethlehem Shipbuilding Co. San Francisco, Cal.
Designers of vessel	Marine Dept., Stand. Oil Co. of California

The hull is constructed on the transverse system with a single steel deck, a short forecastle and a long poop. The vessel's four (double) cargo-tanks extend three feet above the deck, forming an expansion trunk on which are concentrated the hatches, cargo-discharge piping, other piping and deck fittings that might serve as obstructions in the way of handling cargo, hose or freight so that the deck is virtually clear. A bulwark with ample freeing ports connects the poop and forecastle in order that freight may be carried on deck without danger of it being washed away. The forepeak is given over to ballast, the cargo hold being just aft of it. The afterpeak is the fresh-water storage space, and the engine-room is just forward of it. A pump-room is forward of the engine-room and the remainder of the space in the boat is occupied by the cargo tankage.

A steel deck-house on the poop deck contains quarters for the captain and a sales-



General arrangement plans of the Standard Oil Diesel-electric tanker "Standard Service"

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man. A navigating-bridge, pilot-house and chart-room are directly above. The crew's quarters are below decks; so are the galley, mess-room, store-room, and refrigerating space. An unusual feature of the STANDARD SERVICE's equipment is a steel mast, unguyed, the guys being done away with to remove deck obstructions. This mast is an H-steel column, braced with channels carried to the edge of the expansion trunk. It carries three wooden booms for handling cargo, the hose and package freight.

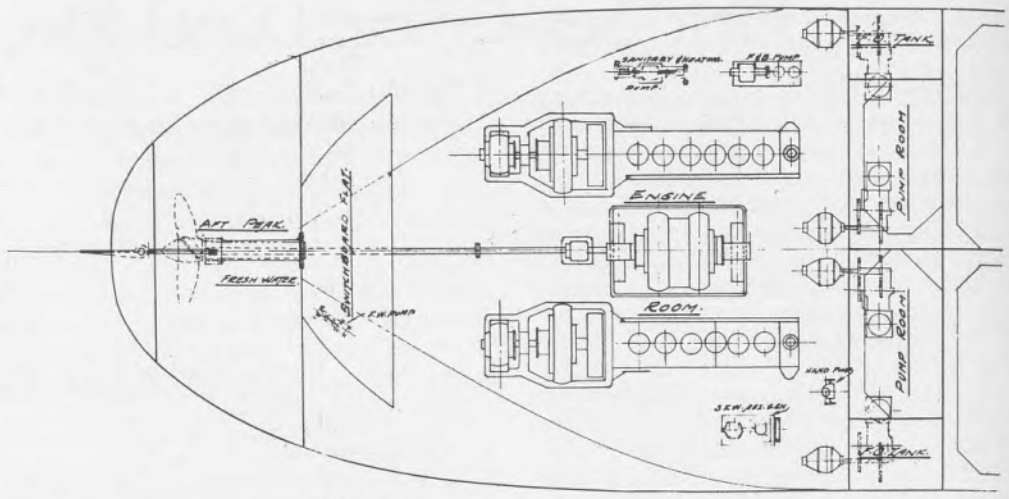
In the engine-room, the most striking features are the compactness of the main power units and the absence of auxiliary engines, except for a small emergency electric generator, driven by a gasoline engine. In each of the Standard Oil Company's earlier Diesel-driven tankers is a considerable installation of auxiliaries, there being two 150 b.h.p. oil engines in the CHARLIE WATSON and two 200 b.h.p. and one 150 b.h.p. oil engines in the W. T. HARPER in addition to the twin propelling Diesel engines.

In the STANDARD SERVICE, however, a practice developed in stationary plants has been adapted to marine use, and the main power-plant is arranged to provide power for the auxiliary apparatus. This main installation consists of twin installations as follows:

Two six-cylinder, four-cycle, Pacific-Werkspoor Diesel engines, each developing 400 brake horsepower at 265 revolutions per minute, are each direct coupled to a 250 volt, 245 kilowatt d.c. generator and (on the same shaft) to a 115 volt, 30 kilowatt exciter. The engines are of the trunk-piston type, with cylinders 335 mm. (13.188 inches) in diameter and with 500 mm. (19.685 inches) piston stroke. They can be operated under the makers' guarantee at 20 per cent. overload for an hour; indeed, a pair of Pacific-Werkspoor Diesel engines already have been operated under virtual 20 per cent. overload for a year in marine service. The Diesel engines were built by the Pacific Diesel Engine Co., Oakland, Cal.

Each engine, generator and exciter, comprises a solid unit, the three having what virtually is one solid shaft, their bedplates being bolted together on a common footing. Mounted on the engine and driven from its own shaft, are circulating, bilge, fuel-oil transfer and lubrication pumps, also a compressor to provide high-pressure injection-air, which is bled to provide a supply of starting air. Owing to the nature of the installation, very little starting-air is required, so there is no auxiliary air-compressor on the ship. Both generators and exciters are compound wound.

Current from the two generators is led to a double-armature propulsion-motor unit consisting of two 300 brake horsepower, 130 r.p.m. 230-volt shunt-wound General Electric motors mounted on the same shaft and having a common base, from which the tail-shaft extends back to the single screw. This is of nine feet three inches diameter with eight feet pitch. It is built-up with bronze blades on a cast-iron hub. The exciters are overhung and oversized, and power is drawn from them for running the auxiliary apparatus—except the cargo pumps. Use of exciters in connection with direct-current generators is necessary because of the Ward Leonard system of control with which the ship is equipped.



Revised engine-room plans of Diesel-electric tanker "Standard Service," showing lay-out of the Pacific-Werkspoor Diesel engines and General Electric generators and motors, etc.

With this installation the engines run always in the same direction, irrespective of the vessel's progress or maneuvers, and all changes in speed or direction are controlled from the bridge or pilot-house by varying the supply of current to the driving motor. Either main Diesel engine will drive the ship at three-quarter speed, meanwhile operating all necessary auxiliaries for her operation, except, of course, the cargo pumps which normally are not in use while the vessel is moving. Either main Diesel engine and generator will drive all the cargo pumps.

The two main generators and the two armatures of the driving motor are connected in series, with one motor armature between the generators in each side of the line. Either motor or generator may be cut out and the circuit at the same time left intact. The exciters are connected through double-throw switches to either of two sets of busses, so that the load of the auxiliaries may be distributed to best advantage.

An important feature of the electrical installation is the absence of any automatic circuit-opening devices. The field windings of the generators are arranged differentially and any excess current in the main line (above that to which the machines are adjusted) will operate to reduce the generator voltage, thus automatically protecting the system from excess strains and at the same time insuring against loss of power at a critical moment, as when the control lever is thrown from full-ahead to full-astern to avoid collision. The controlling rheostat of the system by which the ship's speed and direction is varied is in the engine-room, but is operated from the bridge through a distant control. This reduces the amount and size of the apparatus on the bridge and in the pilot-house.

There are two field rheostats for each generator, and by a double-pole, double-throw switch either can be used. One is for use when the generators are supplying power to the driving motor, and the other is thrown into the circuit when the cargo pumps are being used. In the first condition no adjustment of voltage can be made at the switchboard, but in the second the field can be altered as desired. When the second rheostat is in use the series field of the generator is thrown out of circuit, to prevent a fluctuation of voltage due to heavy starting currents. The field switches of the motors are interlocked with the main line switches to prevent inadvertent short-circuiting of any motor armature by opening its field.

There is a freshwater pump built by the Krogh Manufacturing Company, of San Francisco, and a fire pump supplied by Alberger, of Newburg, N. Y. The sanitary and hot-water service-pump unit was also built by the Krogh concern. This unit consists of a motor mounted between two centrifugal pumps, one of which maintains a supply of water at constant pressure for operating the ship's sanitary appliances, and the other maintaining circulation in a water-heating system that utilizes the exhaust-gases from the main oil-engines.

These gases are led through a tubular heater, the flow being controlled by a by-pass so that any portion of them not needed for heating can have free passage outside. The tubular heater is very simple, being composed only of a container or shell in which are a number of inter-connected water pipes. The flow of hot gases keeps the water in these pipes hot, and the circulating pump already mentioned keeps the water flowing through the heater and radiation system. A supply tank located above the heater insures that it never will become dry and be damaged by the hot gases.

This heating system supplies hot fresh-water for the galley and bath accommodations, heats the living quarters by means of ordinary radiators, and provides means of heating the oil in the engine service-tank, so that it will flow readily.

For use when the vessel is laid-up, or in emergency, there is a seven horsepower gasoline engine coupled to a 3¾ kilowatt 115 volt generator capable of operating the necessary lights. This unit was supplied by the Union Gas Engine Company, Oakland, Cal. There also are two small hand-pumps, one for handling fuel-oil to the daily-service tank and the other for emptying the lubricating oil drain tanks.

The cargo-pump capacity is large. There are four 8" x 10" duplex pumps, built by the Dow Pump & Diesel Engine Co., Alameda, Cal., each connected to one cargo tank. By means of cross-connections, any pump can be connected to any tank. There are separate discharge lines so that four grades of oil can be handled without contamination. Sea suction and overboard discharge are arranged on suction and discharge sides of each pump. These pumps are located in a room of their own, the driving shafts extending back through a bulkhead to the driv-

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ing motors in the engine-room. Thus danger of a spark from a motor igniting gases which might be present in the pumproom is eliminated. This is regarded as something of an innovation. The driving motors are of 30 horsepower each. All electric equipment, both below and above decks, is from the General Electric Company, Schenectady, N. Y.

The deck machinery includes two winches operated from separate water-tight controllers mounted at the cargo-hatch coaming; a windlass fitted with warping heads, a capstan and a steering-engine with electric operation from the pilot-house. All are motor driven and all were supplied bv the Allan-Cunningham Company, Seattle, Wash.

The Foamite system of fire protection has been installed. The Foamite solution is carried in a tank mounted on the expansion trunk, and distribution, in case of need will be through hose.

Her engines under shop test showed the expected economy of fuel consumption and very satisfactory speed regulation. The oil used was the ordinary fuel-oil of 16 degrees Beaumé.

For the lubrication of the main oil-engine there are McCord sight-feed lubricators with leads to both inboard and outboard sides of each cylinder, with indicators to each cylinder. Lubrication is by force feed to bearings, crankpins and wristpins through channels in the crankshaft and connecting rods, and there is a deflector ring on the bottom of the pistons.

The vessel's name was chosen in a contest conducted among the Standard Oil Company's employes, in which several hundred titles were submitted.

The exact number of men the ship will carry has not yet been determined. The plan of operation of the STANDARD SERVICE contemplates the greatest possible economies, such as can be attained with any kind of machinery only in long runs. It is contemplated that the main power-plant, after being started-up at the beginning of a voyage, will not be shut-down entirely until the ship is made fast at her pier and her cargo is pumped out, and only then in case she is not to make a return voyage immediately.

Because of the unusual nature of this vessel, we feel we cannot conclude this article without reference to the fact that while both the Standard Oil Company of California and the Asiatic Petroleum Company of New York appear to have had every reasonable success with their motorships, all attempts to adopt Diesel power made by the Standard Oil Company of New Jersey seem to have been followed by a run of bad luck and disappointment. There must be some cause for this, and it can hardly be due to the Diesel system as a power unit because of the successful operation of hundreds of motor-vessels in the world's fleet to every one failure.

OIL LIGHTER FOR NEW YORK HARBOR

On the trials of the new tank-lighter BESSIE, referred to in our last issue as having been powered with a 95 h.p. Wolverine oil-engine to the order of the Phoenix Fuel Supply Co. of New York City, a very thorough—though short—test was given to the engine as well as to the old hull due to heavy weather being met immediately upon leaving the inner channel off Bridgeport, Conn.

When she left the dock a slight ground swell indicated dirty weather beyond the Light, and in this no one aboard was disappointed. The vessel was in ballast and her machinery, being aft of midships, raised her bow and subjected her to the buffetings of the wind. When the first big wave was met those on deck were washed aft, injuring them severely as they came in contact with the deck fittings. It was found that the weather was too rough to carry out extended trials, so after one-half hour's run she was turned around for port.

The skipper of the vessel had never been aboard the vessel before, nor did he see the engine until she arrived back in port. He first went aboard at the same time as our representative. Yet, when he took the wheel, as well as the handling of the engine-speed controls that are carried to the helm, he found she handled with the greatest ease. Consequenty, he was somewhat amazed. The engine was started when cold and only a few seconds elapsed from the time the "ahead" signal was given until the engine turned-up at full speed.

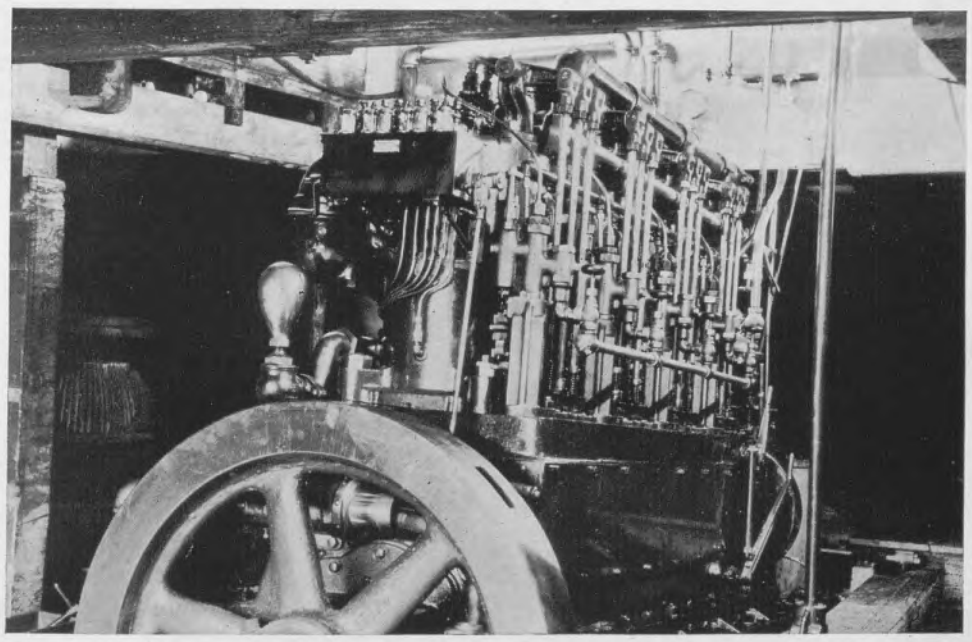
The BESSIE will carry 75 tons of oil in bulk in New York Harbor, three tank linings having been fitted to the wooden hull for this purpose. She is 65′ long by 18′ breadth and 6′ draft, and her 95 h.p. oil-engine turns a 46″ propeller. She will be manned by two men, namely the Captain and deck-hand—the latter looking after the engine. When fully loaded the boat will average about 8 knots.

Oil tank-lighter "Bessie," powered with 95 b.h.p. Wolverine oil-engine

COMMANDER FISHER ON DIESEL PROGRESS

At a recent meeting of the First Battalion of the Naval Reserves of the Twelfth District at San Francisco, Commander J. O. Fisher, U.S.N., gave an address on the development of Diesel power. He enumerated the early attempts to design and produce an internal-combustion engine, traced the history of the various patented designs and discussed the economic principles of Diesel and heavy-oil engines as compared with gasoline-engines.

He pointed out that one reason for the somewhat slow progress of the heavy-oil engine in the United States lay in the tremendous supply of cheap fuel with high cost of labor, while in Europe labor is cheap and fuel scarce and high priced. The initial cost is, therefore, outweighed by the remarkable economy of operation, while in this country he believed that the high cost of the Diesel-engine offsets the operating economy. However, he further stated that the Diesel-engine would predominate in the future propulsion of ships, but doubted if the steam-engine would ever be entirely supplanted. The growth of Diesel installations from 297 in 1914 to 1,620 in 1922—an increase of 600 per cent.—is significant.



The engine-room of the "Bessie"

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"Drechtdyk" of the Holland-American Line

New Harland & Wolff Built Vessel

On March 22nd the new motorship DRECHTDYK was added to the fleet of the Holland-America Line, having been delivered by Harland & Wolff's Greenock Yard. As previously stated she is a sister-ship to the DINTELDYK now in service between Holland and our Pacific coast ports, and has the following dimensions:

Length o.a.	502′0″
Breadth	62′0″
Depth	38′6″
Gross Tonnage	9,500
Horse Power, total	6,000 i.h.p.

Comfortable accommodation is arranged for 12 passengers amidships in six two-berth staterooms.

The propelling machinery, which was constructed by Harland & Wolff, Ltd., at their Diesel Engine Works, Glasgow, consists of two standard eight-cylinder four-cycle Diesel engines of the Burmeister & Wain crosshead type developing a normal-service horse-power of 6,000 i.h.p. at 115 revolutions per minute. Compressed-air for fuel-injection is provided from two three-stage air-compressors mounted in tandem at the forward end of each engine, and driven off an extension of the crankshaft.

On the port side of the motor room are fitted four 100 k.w. electric generating sets, each set driven by a three-cylinder four-cycle Diesel-engine, and generating direct-current at 220 volts.

Late News Items

A 350 b.h.p. Bolinder oil-engine is to be installed in the tug CZAR, at Vancouver, B. C.

Wm. Wilhelmsen's new 8,000 ton d.w.c. motorship TALISMAN ran trials on April 10th at the Deutsche Werft, Hamburg.

It is reported that two 170 ft. Diesel-electric ferries will be built for the Yonkers-Alpine service on the River Hudson of the Westchester Ferry Corporation.

Some motor barges of 2,000 tons d.w. will probably be built for Witherlee-Sherman Company, of Port Henry and of New York City, for the purpose of transporting 100,000 tons of ore.

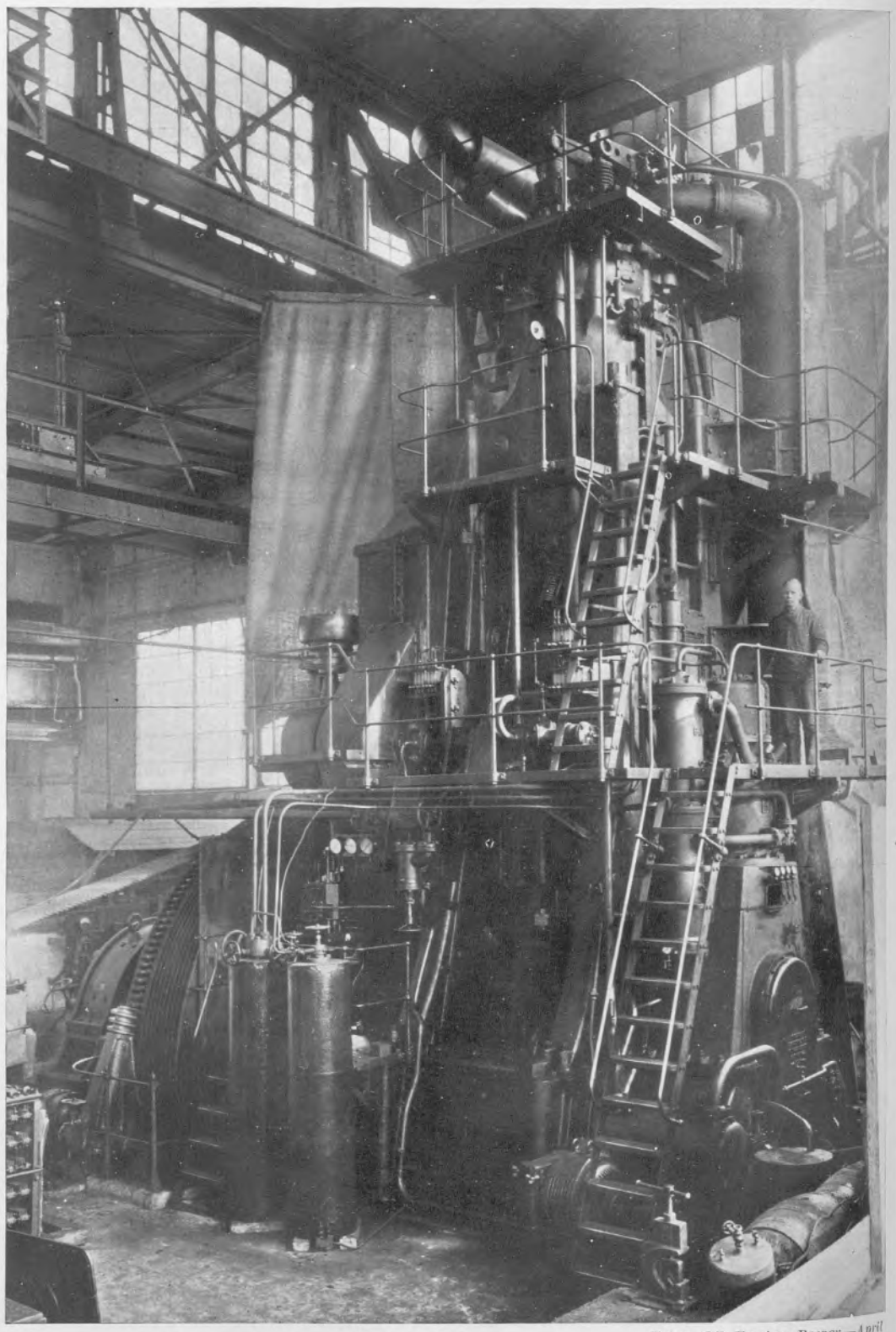
LA PLAYA, one of the three 325′ Diesel-electric motorships building for the United Fruit Co., of Boston, was launched on April 17th at Cammell-Laird's yard, Birkenhead, England.

Elder Dempster Co.'s new twin-screw 6,500 gross tons motorship EDIBA successfully ran trials on April 18th. Built by Harland & Wolff, this vessel has twin 3,200 i.h.p. (at 115 r.p.m.) Harland B. & W. Diesel engines.

In two Government dredges for service in Texas now being built at the John Jacobson shipyard, 300 b.h.p. Worthington oil-engines connected to 12″ pump will be installed. There also will be a 50 h.p. oil-engine generator set for auxiliary power.

Two motorships of 10,300 tons d.w.c. with Danish-built Burmeister & Wain Diesel-engines have been ordered by Mitsui & Company, the well-known Japanese shipowners, from the Götaverken, of Göteborg. Both are single-screw vessels, and each will be powered with a 2,400 shaft h.p. long-stroke type slow-speed motor.

LAGUNDA, a new twin-screw motorship built to the order of the Pacific Steam Navigation Co., of London, was launched on April 19th from Harland & Wolff's Govan yard. She is a vessel of 6,500 gross tons, 433′ length, by 54′ breadth and 36′ depth, and will be equipped with two 6-cylinder Harland-B. & W. Diesel engines. Accommodations will be provided for twelve passengers and a crew of 60 officers, engineers and men. All the deck and auxiliary engine-room machinery will be electrically driven.



From Oil Engine Power—April

1,000 B.H.P. SINGLE-CRANK DOUBLE-ACTING OIL-ENGINE ON THE TEST BED AT THE BURMEISTER & WAIN WORKS

This engine has recently made a continuous day and night run for an entire month at full load and shown the remarkably low fuel-consumption of only 0.345 lb. of oil per b.h.p. hour, inclusive of the consumption of the auxiliary machinery. It takes up less space than a steam turbine of the same power and weighs five per cent less. It is the test unit of the two six-cylinder double-acting Diesel engines of 6,750 b.h.p. each, which Burmeister & Wain are building in Copenhagen for a new 17-knot transatlantic passenger vessel ordered by the Swedish-American Line

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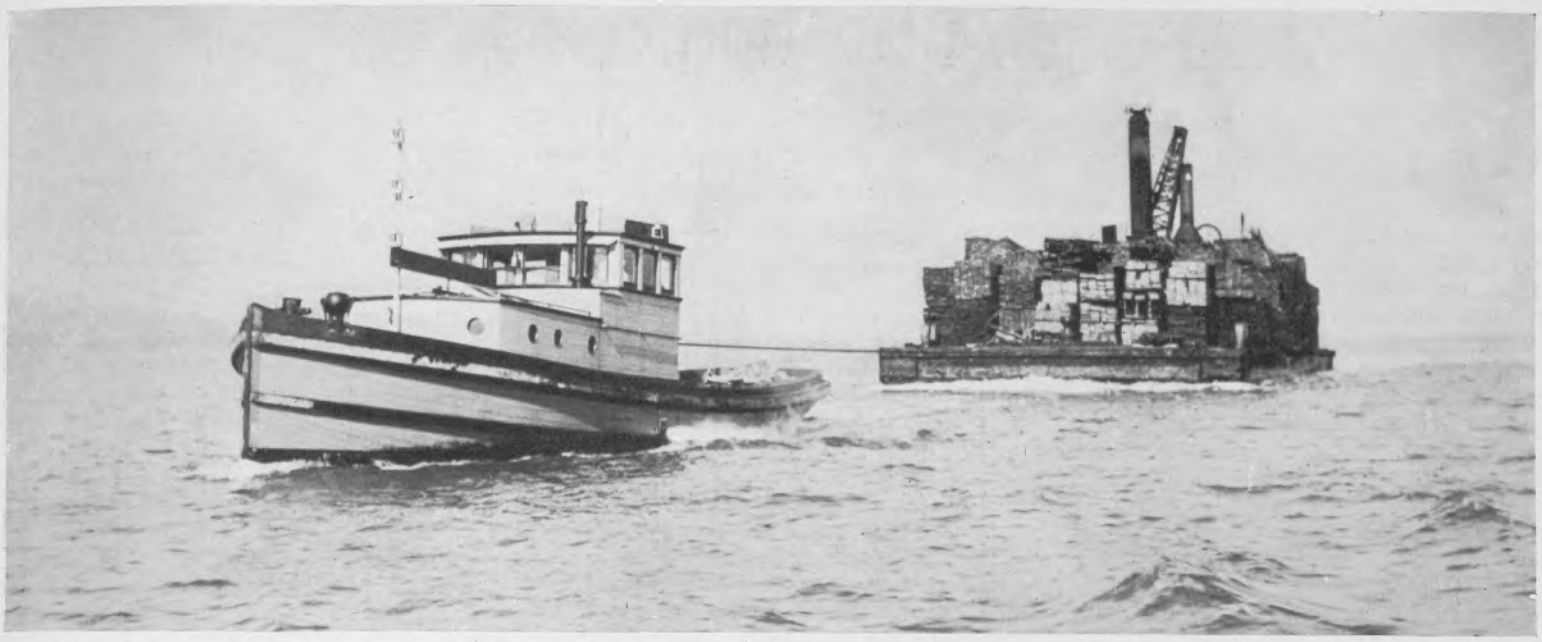

Coos Bay Lumber Co. Enterprise Diesel-tug towing barge on trial-trip

Coos Bay Diesel-Tug Trials

An Interesting Enterprise Engine Installation

Official trials of the Diesel-tug built for the Coos Bay Lumber Co. of Coos Bay, Ore., by Nunes Bros. of Sacramento, Calif., gave interesting results. It will be remembered that this tug was described and her plans published in the December, 1922, issue of MOTORSHIP and that she is 57′0″ length over all, 16′0″ breadth, 6′2″ depth of hold, and 6′6″ draft, 34 gross and 20 net tons. She is powered with a four-cylinder 10½″ x 14″ Enterprise Diesel-engine of 165 brake h.p. developed at 320 r.p.m.

After being launched, on which occasion she was christened by Mrs. David W. Dickie, wife of the designer, the tug was towed to San Francisco to have the Enterprise Diesel-engine installed. To facilitate this work the cabin trunk had been constructed as a unit but not fastened in place, and was lifted off as shown in the illustrations, being replaced and bolted down after the engine was lowered on to the bed.

In running the trials of this tug it is worthy of note that actual operating conditions prevailed, the tug towing a 130′ x 35′ barge loaded with 265,000 board feet of lumber, a real test as the illustration indicates. This method of testing a tow-boat is recommended for all such craft, as it affords a test under exactly the conditions which will exist in service. To run a tug around a harbor without a tow and with light load on the engine and propeller is actually far from a complete test of the machinery.

Many engines will operate perfectly when running light, but will develop need of minor adjustments when run at peak load which a heavy tow produces.

The Coos Bay tug handled this barge to the satisfaction of all, making an average speed of 4.587 knots over the California City mile course. While running light without a tow she attained 8.27 knots when floating at her designed water line, and operating at 293 r.p.m., which gives 4′8″ draft forward and 6′6″ aft. In order to determine the effect on speed of a change of trim, the anchor and chain were moved aft to reduce the draft 4″ forward and increase it 4″ aft. Under this new trim the speed when running light was 8.43 knots and towing the barge 4.097 knots.

Using 24 degrees Beaumé fuel-oil the consumption was recorded as 9.57 gallons per hour when delivering 167.8 brake h.p. at 294.5 r.p.m., equal to 0.4275 lb. per h.p. hour, but the method of securing the brake power in the boat is not given. However, this consumption is equivalent to 17.53 h.p. per gallon. The maximum temperature of this fuel-oil was 110 deg. F., of the lubricating-oil 104 deg. F., of the circulating-water at the intake 56 deg. F., and at the outlet 138 deg. F.

This boat is typical of the efficient motor-tug so popular on the West coast and which should be more often found in our harbors in other sections of the country. The advantage of the location of the pilot-house accessible both to the engine-room and to the towing-bitts has not evidently been appreciated on our Eastern harbor tugs.

MOTOR BARGES FOR NEW YORK CANAL

A large fleet of barges for service between Buffalo and New York City through the Barge Canal is contemplated by the Interstate Vessel Owners, Inc., of Buffalo, N. Y. Plans and specifications have been prepared by Kindlund & Drake, naval architects of New York, for their fleet of five motor-barges and forty bulk-cargo dumb-barges and bids are being obtained. Each of these vessels will be approximately 100′-0″ long, 21′-6″ breadth and 13′-0″ draft. The towing barges will have each a 375 b.h.p oil-engine.

Lowering the Enterprise Diesel-engine into the boat

Placing the house on after lowering the engine into the boat

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Mexican Fuel-Oil With Diesel Engines

Problems Affecting Use of 14 Deg. Beaumé Boiler Fuel Discussed from First Hand Experiences

By CHIEF-ENGINEER A. B. NEWELL

MOTORSHIP owners have had a try at cheap fuel. In some instances the fuel bill has been divided by almost two—one point five is perhaps nearer. They are greatly encouraged; while many Diesel engineers feel that they have been intrigued. The saving effected has been cut from freight rates or added to the profits, when the occasion justified it. Business men—shipowners—think in terms of dollars and cents as depicted on the credit side of the balance sheet. That is why just as surely as motorships have come to stay, their burning of the cheapest, and consequently poorest, grades of fuel is inevitable. It can be done and will be done!

However, in spite of the claims made by certain oil-engine builders that their motors will burn heavy, low-grade boiler fuels, there are none who can honestly say that their engines will do it with the same degree of satisfaction attained with a better product, if the factor of initial fuel cost be eliminated. Thus the problem has not been completely solved, but it is well under way and a satisfactory solution seems imminent.

But the average motor-engineer is neither competent to judge nor has he the equipment on board to determine the net heating-value, flash-point, sulphur-content, specific-gravity, ash, refuse, etc., of the different fuel-oils; while most shipowners and their purchasing agents are more interested in the net price than any of these important items. It is then useless to mention fuel specifications, for purchases will be made at the lowest price regardless of quality, and it will be up to the engineers to see that the Diesels burn it.

The high percentage of sulphur contained in most low grade fuels seems to be a source of worry to many who are not well informed with regard to its action. An oil-engine burning sulphurous fuel need not be damaged while in operation, for sulphur fumes, under normal running temperatures, are inert, and will be expelled with the other exhaust gases. The only danger lies in stopping the motor while burning sulphurous fuel and allowing it to cool to the point where water (formed as condensate upon the cylinder walls and other interior surfaces) becomes sulphurous acid as the result of its absorption of the sulphur fumes present, and causes pitting.

In burning boiler fuel it is necessary to have a small tank of light high-grade fuel —such as gas-oil, or Diesel oil—to burn while starting, maneuvering, and just prior to shutting down. If this fuel be non-sulphurous, then the sulphur problem is automatically taken care of with its use. This offers no serious handicap to the installation, and is not a real complication.

It is well to mention that the small tank just referred to should be provided with an adequate heating arrangement. The light fuel should be heated for use in order that its passage through the engine fuel pumps will heat them in preparation for the heavy fuel to follow. If this be not done the fuel-pumps may become chilled, and when the heavy fuel enters them it will congeal causing a sluggish action of the valves and undue friction in the fuel lines, in which event the engine will stop and some time will be lost in starting it again.

The high percentage of asphaltic substances such as ash contained in most low-grade fuels is difficult to atomize properly and burn completely. Therein rests the trouble in attempting to burn boiler-fuel in Diesel motors. Too much stress cannot be placed on this point. This ash should be extracted.

If the ash or asphalt is not completely burned within the motor large quantities of a hard, black and sticky substance will accumulate upon the walls of the cylinder liners and will be picked-up by the piston rings, sticking them in their grooves and causing them and the cylinder walls to wear excessively as the result of heavy friction. Eventually numerous delays in port will result, while pistons are being pulled and cleaned, rings removed and cleaned or renewed.

The development of a suitable atomizing apparatus is entirely the work of the engine builder; however, the operating engineer must keep it in good working order.

Although it is not good practice, it is possible to burn a good grade of Diesel engine fuel while the atomizers and fuel valves are in need of cleaning or adjustment, and with no apparent damage to the motor. No such liberty can be taken while burning Mexican boiler fuel. The greatest care must be exercised in keeping the atomizers clean and the fuel valves adjusted. Oil engines will give less trouble as the result of a low fuel temperature than as the result of carelessly handled fuel valves and atomizers.

To burn boiler fuel the application of heat is essential. By raising the temperature of fuel-oil the viscosity is lowered until the gassing point is reached, which in most grades of fuel takes place at not more than 180 degrees Fahr., after which it is inclined to slightly thicken again. At about 225 degrees Fahr. carbon will form. The greatest changes in viscosity takes place between the lowest temperature at which fuel-oil might be carried and 130 degrees. Between 130 and 150 degrees the change is sufficient to help atomization, and with certain grades of fuel a farther raise in temperature—not to exceed 180 degrees is helpful.

My experience has been—with Mexican Crude 14.6 degrees Beaumé—that by having the fuel enter the injection pumps at 150 degrees Fahr. the lowest practical viscosity is gained, while the possibility of gas bound fuel-pumps is eliminated. At that temperature the Saybolt Viscosity in seconds is 950, which is very low. However, with a poorer grade of fuel such fine results could not be attained with a temperature so low.

If by means of a secondary heating arrangement the fuel be heated again, after it leaves the engine fuel-pumps and before it reaches the fuel valves, it is doubtful whether any good would result. There would be the danger of carbonization as the result of too high temperature, and should it start, the atomizers and burner plates would clog with obvious results. At any rate heat losses as the result of the passage of the fuel through the injection pumps and fuel lines are so small that they may be neglected. It is safe to assume that the fuel will reach the fuel valves at very nearly the same temperature at which it enters the injection pumps.

While burning boiler-fuel of a high flash-point it is advisable to set the time of injection from one to three degrees ahead of the normal setting for Diesel engine fuel; the amount of lead varying in accordance with the maximum speed of the engine. It is also advisable, where air injection is used, with a high viscosity fuel, to raise the injection-air pressure to the highest point consistent with good practice and safety. Aside from the above suggestions, no changes should be made in the original setting and clearances of the engine except on the engine builders' recommendation.

With careful, intelligent handling of boiler fuels, it is safe to experiment with large Diesels without fear of delay to the ship, but with low-powered motors the problem becomes greater, consequently owners of small motor vessels should not be in too great haste to take advantage of the low price of boiler fuel unless the ash content is first removed. Their turn will come in due time. However, if a man made a serious effort to burn boiler fuel in a Ford he should be admired for his courage and not condemned as a fool, for he might stumble on a method of doing it, although the chances are that he would pay a fair sum to get his engine cleaned up.

Should any engine fail to burn such low-grade fuel neither the engine nor the engineer should be condemned, for its present use in certain installations was not accomplished without expensive experiments, and it is only recently that satisfactory returns are coming in on the money invested in these experiments.

NEARLY 17,000 HORSEPOWER IN ONE MOTORSHIP

In the Swedish America Line's new passenger motor-liner building at Armstrong Whitworths and having Burmeister & Wain double-acting, four-cycle Diesel engines aggregating 13,500 shaft horsepower, there will be installed in addition six Diesel-driven dynamos aggregating 3,150 brake h.p. So the total power of this vessel will be 16,650 brake horsepower. She is due to be placed in service in the Fall of 1924.

OIL ENGINE POWER
A Companion Journal to MOTORSHIP
$1.00 Domestic $2.00 Canada $2.50 Foreign

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Worthington oil-engined sand and gravel dredge "Elizabeth Pfeil," with capacity of 7,000 tons per day. She is owned by the Iron City Sand Co., Pittsburg, Pa., and has a 300 b.h.p. engine, driving a 270 K.V.A. Westinghouse generator. Length 160 ft., breadth 40 ft., draft 4½ ft. Contracted for by the Bucyrus Company

Interesting News and Notes from Everywhere

The Bolinder-engined motor-barge SOCONY 5 recently rescued four men from a disabled boat when en route for Boston.

Six more reduction-geared Diesel-driven motorships of 10,000 tons d.w.c. are to be built for the Hamburg-America Line.

An order for a full-powered Diesel-driven yacht of over 200 ft. length may be placed during the next 30 days by a prominent yachtsman.

The Foss Launch & Tug Boat Co.'s tug WINONA is being equipped with a 100 h.p. Diesel-engine at the plant of the Ballard Marine Railway, Ballard, Wash.

A 6,000 tons Diesel-driven motorship has been ordered by Biorn, Biornstad & Co., Kristiania, Norway, from the Odense Shipyard, at a cost of about $410,000.

The San Francisco office of Mr. S. Burke Smith, representing the New London Ship & Engine Company in the western territory has been moved to 203 Balfour Building.

All the bids on the 80 ft. Diesel-electric towboat for the U. S. War Department's Cumberland River service (See page 271 April 1923) have been rejected as excessive.

The Ocean Line will shortly place into service the two 6,000 tons motorships now building at Krupp's Kiel-Gaarden plant. The owning director of the Ocean Line is H. Schuldt.

The 11,000 tons d.w. passenger motorship, DUMANA, of the British India Steam Navigation Co. recently ran trials. She is propelled by twin 2,000 i.h.p. North Britain Diesel engines.

Sea trials of McIvers & Co.'s (Liverpool, England) new motorship ARABY, 4,934 tons, were run at the end of March by the builders, Archibald McMillan & Son, Ltd., Dumbarton, Scotland.

World's Record of New Construction, Ships' Performances and Other Matters of Note in the Motorship Field

Another 14,000 tons d,w,c. 6,000 i.h.p. Diesel-driven motorship has just been laid down at Harland & Wolff's Belfast shipyard for the Eastern trade. A similar motorship is on the stocks.

PFEIL, a 90′ x 16′6″ x 9′3″ cargo vessel fitted with a 260 b.h.p. Körting Diesel engine has just been launched at Martin, Sengers and David Co.'s. yard in Hamburg, to the order of Fritz Frank of the same city.

An order has been placed by the U. S. Government for a three-cylinder, four-cycle type 110 b.h.p. Pacific-Werkspoor Diesel engine for installation in the tug SHILLING in service at Philadelphia Navy Yard.

Twin eight-cylinder, 30″ diameter, four-cycle, airless-injection Vickers Diesel-engines, will be installed in the new cattle motorship ordered by the Donaldson Line for their Canada-England trade.

One of the largest established and most respected builders of marine and stationary oil-engines is desirous of securing a New York agent. Sealed letters addressed to this office marked "Agency" will be forwarded to the company.

GUILLEMOT, a 102 ft. lightship has just been completed at the Cran & Somerville shipyard, Leith, to the order of the Commissioners of Irish Lights, Dublin. Two 13 b.h.p. Robey oil-engines furnish the power for the air-compressor.

Trials of the motorship HIREN, 2,000 tons d.w.c., were recently run by the builders, the Langesunds Mek Verksted, for Kristiania owners. Twin 250 shaft h.p. Bolinder oil-engines are installed, which gave her a speed of 9½ knots.

Preparatory to leaving for the Arctic in the fur-trading and whaling service, the schooner ARCTIC, owned by H. Liebes & Co., of San Francisco, and recently fitted with a 350 h.p. Atlas-Imperial engine, was loading at Pier 25, San Francisco.

In a recent issue of THE MARINE JOURNAL the fuel consumption of the motorship MUENSTERLAND is given as "three pounds per indicated horse-power hour." However, it is about one-tenth of this amount, being 0.3 lb. per i.h.p. hour.

According to Dr. H. Fujishama, of the Nippon Yusen Kaisha, the two 10,000 tons Diesel-driven motorships ordered by them (as announced in our last issue) will be placed in service between Seattle and the Orient. They will be ready in about a year.

So satisfied were the directors of the Standard Oil Company with the results of the trials of the Diesel-electric tanker STANDARD SERVICE that they at once ordered a second set of 400 b.h.p. Pacific-Werkspoor engines and General Electric drive for a duplicate tanker.

In the Diesel motor yacht now building for Sir James Knott, Newcastle-on-Tyne, England, by the Furness Shipbuilding Company, Sulzer Diesel engines are being installed. For auxiliary power there will be three Gardner surface-ignition oil-engines of 46 b.h.p. at 450 r.p.m.

Our news articles of the large Diesel-driven passenger liners building abroad have evidently produced considerable interest in this country, for inquiries have already been made by a New York shipowning concern for prices on two motorships of 12,000 and 15,000 tons respectively.

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Another interesting paper has been read by P. Belyavin. This one is entitled "Marine Oil-Engine Installations and Auxiliaries," and was read before the North East Coast Institution of Engineers and Shipbuilders. The address of the Institution is Bolbec Hall, Newcastle-on-Tyne, England.

"Results of Test Bed and Sea Trials of the Beardmore-Tosi engine" is the title of an interesting paper read on March 13th before the Institution of Engineers & Shipbuilders in Scotland by Robert Love. At the same meeting A. I. Nicholson read a paper entitled "Some Oil Engine Experiments."

According to Brunsgaard Kiosterud & Co., Drammen, Norway, the principal reason for their being enabled to pay a dividend of 10 per cent. is the profit made on the charter of their Polar-Diesel engined tanker HAMLET, which continues until February, 1924. After depreciation they show a net surplus of 3,200,000 kroners.

The French naval authorities have ordered six 1,000 ton surface-displacement submarines of the Requin type, to be equipped with twin 2,000 shaft horsepower Diesel engines and electric motors, the latter to be built by the Societe Generale Electrique of Nancy. Orders for six additional submersibles will be placed shortly.

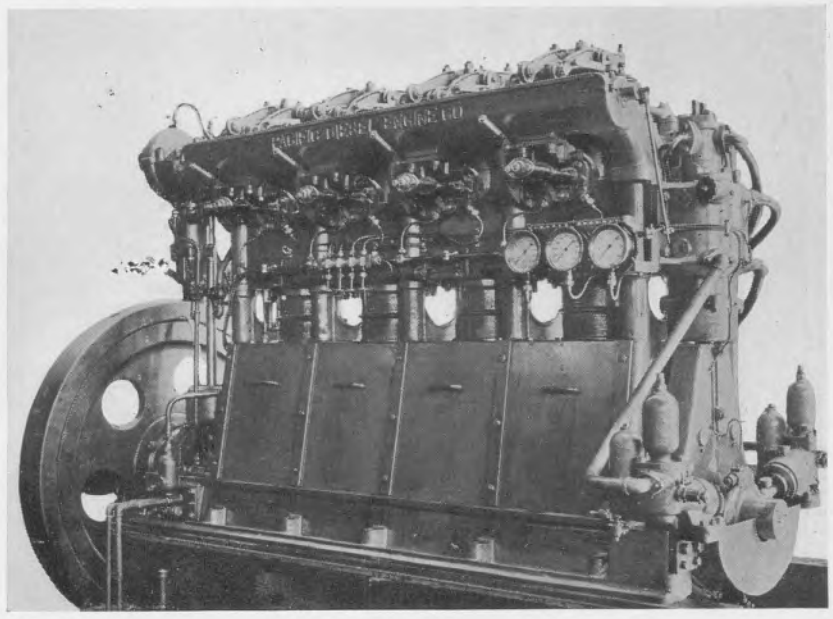
An office has been opened in Boston by Chas. Cory & Sons, Inc., manufacturers of ships' telegraphs, signalling, communicating and lighting systems. The new office is located at 88 Broad Street, in charge of Mr. A. E. Sargent, an electrical engineer, for many years connected with the Fore River plant of the Bethlehem Shipbuilding Corporation.

The steamer MAGUNKOOK has been purchased by the Moore Shipbuilding Co., Oakland, Calif., from the U. S. Shipping Board, for conversion to Pacific-Werkspoor Diesel engine power. When completed she will be delivered to the Oceanic Steamship Co. of San Francisco, for operation between San Francisco, Honolulu, South Seas Ports and Australia.

Yet another shipbuilding firm is on the point of taking up a license of the well-known Sulzer type of oil-engine in England, making a total of six licensees in England alone. There are four shipbuilding firms acting as licensees both for the Sulzer and the Cammel-Laird-Fullugar engines, which represent about 43% of the 28 types now being constructed in 24 yards.

The war-time built wooden auxiliary motor-schooner LA MERCED, 2,700 tons d.w.c., has just been purchased by Walter Scammel of San Francisco, Calif., for $20,100. When we consider the prices secured for the Shipping Board's wooden vessels, this is quite an excellent price. The LA MERCED was built at Benecia, Cal., and is powered with a 320 b.h.p. Bolinder oil-engine.

G. H. Froebel has been appointed marine sales manager of the Westinghouse Electric & Mfg. Co. at their New York office succeeding the late D. D. Faris. Mr. Froebel entered the employ of the Westinghouse company in 1912. He served in the army as a lieutenant of engineers during the war. He is a member of the American Society of Military Engineers and an associate member of the American Institute of Electrical Engineers.



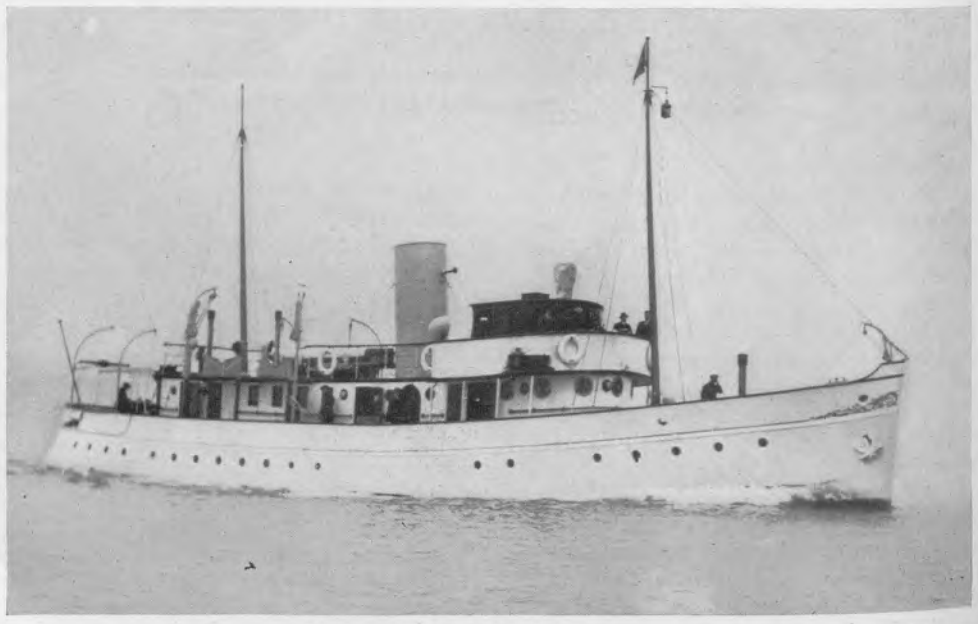
A 150-b.h.p. Pacific-Werkspoor Diesel engine recently supplied to the U. S. Coastguard at Baltimore

A very comprehensive article on the powering of motorships was read on March 22 by K. C. Barnaby, B. Sc., before the Institution of British Naval Architects. Space conditions prevent our publishing the paper, but we believe copies can be secured from the Secretary in London. Mr. Barnaby suggested that the use of reduction gears is the best solution as well as the cheapest for overcoming the propeller speed difficulty.

Three Diesel-engined cargo motorships have been ordered by Andrew Weir & Co., Glasgow, from Harland & Wolff, in which Harland & Wolff-Burmeister & Wain type Diesel engines will be installed. While this is the first adoption of motor power by this well-known company, we recall that Andrew Weir just prior to the war was in California representing a group headed by Lord Pirrie for the purpose of purchasing the Union Oil Co.

According to Lloyds' returns for the quarter ending March, 1923, motorships of over 1,000 tons under construction amount to 327,232 gross tons (about half a million tons d.w.c.). Since that date a number of very large motorships have been ordered. Also, according to Lloyds 50 per cent. of the output of merchant ships built in Holland were oil-engine driven, while in Denmark over 75 per cent. were motorships.

Following a six weeks' non-stop test run of the new 3,000 b.h.p. Bethlehem two-cycle Diesel-engine, it has been decided, says J. J. Tynan of the Bethlehem Shipbuilding Co.'s Union plant, to start building these engines at the Potero works with Frank Neitzel in charge of the construction work. At South Bethlehem the Diesel engine construction is to be continued under G. W. Struble who has replaced Arthur West, the latter having taken a position in another department.



Vickers-Petters oil-engined motor-yacht "Llys-Helig" recently built in Great Britain

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On their last westward run the MISSOURIAN of the United American Lines and the geared motorship MUENSTERLAND of the Hamburg-American Company left Hamburg on the same day at the same hour. In light weather the MUENSTERLAND made better speed than the MISSOURIAN which was well loaded down. In moderate and heavy weather, however, the MISSOURIAN was faster. The two vessels hugged one another all the way across, and arrived in New York within four hours of each other. The MISSOURIAN has direct Diesel drive.

The Salmon Bay shipyard of the Fishing Vessel Owners Marine Ways, Inc., is busy removing old gasoline-engines and installing Diesel and other type oil-engines in seven vessels of the Seattle halibut fleet. The installations being made are a 100 h.p. Enterprise Diesel in the schooner KODIAK, 110 h.p. Frisco-Standard surface-ignition oil-engine in the SEYMOUR, LIBERTY, and POLARIS, also in Olaf Swenson & Co.'s Arctic trader CHUKOTSK, and 80 h.p. Gulowsen-Grei oil-engines in the two halibut schooners OMANEY and ORIENT.

The Netherlands Steamship Company (Stoomvaart Maatschappij Nederland) have ordered the conversion of their steamship BINTANG to single-screw Sulzer-Diesel engined direct-drive, as well as having arranged for the conversion of a sister steamer to the BINTANG. In each of these vessels a 3,500 shaft h.p. 6-cylinder, two-cycle Sulzer engine will be installed. The BINTANG is of 6,548 gross tons and was built at the Fyenoord Shipyard, Rotterdam, in 1916. Her present steam engines consist of a triple-expansion, three-cylinder unit, 28″ x 46″ x 77″ x 54″. Her length is 417′7″ b.p. by 54.5′ breadth.

Now under construction by the Rancocas Construction Co. is a small motor-tug for the Philadelphia Paper Mfg. Co. of a type much in favor among tow-boat men. She is from designs by J. Murray Watts of Philadelphia, and is 50′ long, 12′ breadth, light draft 3′6″ and 4′6″ loaded. She will be used to tow four 97′ by 17′ barges and will perform hard service. A three-cylinder Mianus Diesel-engine of 45 h.p. will turn a 40″ propeller. A 32-volt electric light plant, a Mianus air-compressor and a 3½″ rotary wrecking pump will also be fitted. A stack with water-cooled muffler will silence the exhaust. She will operate where the bridge clearance is 11′2″ and she will have six inches to spare within this clearance.

Barclay, Curle & Co., have just laid the keel for a new single screw motorship of about 6,000 tons d.w. into which will be fitted the 2,250 s.h.p. three-cylinder North British double-acting two-cycle engine, at present being erected on the test bed at the works of the North British Diesel Engine Co., Glasgow, Scotland. The vessel is being built to specification issued by a well-known shipowning firm, and will represent fourth type of Diesel engine, in which this concern is interested. The engine will be running towards the middle of the year, and the vessel should run her trials early in the new year. Barclay Curle's also have a large motorship on the ways for the Harrison & Dixon SS. Co.

According to the annual report of the Deutsche Werft of Hamburg, Germany, the financial year 1922 was profitable. The gross earnings were 115 million marks, (14,600,000 M. in 1921) inclusive of a sum of 811,699 M. carried forward from 1921. After deducting 59.06 million marks for depreciation there remains a net profit of 55.94 million marks. Of this amount 2.80 millions are placed in reserve, 30 millions assigned for the cost of building houses for employees, 30 per cent dividend has been distributed and 5.14 millions carried forward. Six motorships with a total deadweight capacity of 39,400 tons and 9,300 h.p. and 12 steamers were delivered in 1922, but mostly motorships are now on order.

ITAGUASSU is the name of a new motorship now completing in South America at the yard of the Companhia Nacional de Navegaceo Costeira of Rio de Janeiro, Brazil, who design, construct and operate their own fleet, which includes the 1,480 tons gross 580 b.h.p. Sulzer Diesel-engined vessel ITAMARACA. The ITAGUASSU is being powered with twin 520 b.h.p. Sulzer two-cycle Diesels, and will have a speed of about 10 knots. This well-known Brazilian shipowning and shipbuilding firm, which is a subscriber to MOTORSHIP, has planned a larger passenger liner which they propose to build, and install Sulzer Diesels. This vessel is to be of 6,000 shaft h.p. on twin screws. She will have commodious passenger accommodations and 3,500 tons d.w.c.

A report recently appeared in the NEW YORK JOURNAL OF COMMERCE that the Hamburg motor-vessel LOKI has completed satisfactory trials after undergoing extensive alterations at the Germania Yard, Kiel, and that she was originally a motor-vessel but upon going into American ownership was converted to a steamer. Furthermore, that she has now been bought by Hamburg shipowners and has been reconverted to Diesel power. Obviously there is some inaccuracy in this report as the LOKI was in New York harbor some weeks ago, is still under the control of one of the Allied Commissions, and is under charter to the German American Petroleum Company, which is associated with the Standard Oil Co. of New Jersey.

In the 15″ Diesel-electric dredge now building for the Longview, Wash., plant of the Long Bell Lumber Co., a Pacific-Werkspoor Diesel engine is being installed in conjunction with General Electric generators and Allis-Chalmers motors. The vessel was designed by L. H. Polhemus, general manager of the Port of Portland, Ore., and is being constructed by H. L. Shephard at Portland, Ore. A Pacific-Werkspoor Diesel engine will be direct-connected to a 450 K.V.A. alternating current generator 2,300 volt, three phase 60-cycle. This dredge is quite different from the 20″ Diesel-electric dredge of similar type which has been designed by Mr. Polhemus for the Port of Portland, and in which two 750 b.h.p. McIntosh & Seymour engines are being installed.

The new Burmeister & Wain double-acting, four-cycle Diesel engine will, besides being built for twin-screw installations, also be built as a long-stroke engine for single-screw ships, thereby permitting a double-acting engine to be used in larger cargo and passenger ships, such as formerly have been fitted with Burmeister & Wain single-acting Diesel engines and twin-screws, with the consequent saving. Diesel engines of the new type for single-screw ships can be built up to 9,000 b.h.p. The fuel consumption has worked out at 0.286 lb. per i.h.p. hour, or 0.341 per b.h.p. hour for the main engines with the necessary auxiliary machinery included. The plant takes up less space than a steam turbine of same horsepower and has by comparison worked out at 5% less weight.

The 135 ft. Nelseco Diesel-engined yacht EDYTHE was recently reported as purchased from John F. Craig by George Whittell, Jr., of San Francisco. Mr. Whittell also is the captain of his yacht, which carries a crew of ten men. An interesting item of her equipment is a Schrader diving outfit which is used when it is desired to hunt pearls on the yacht's cruises in Southern waters. She has in addition to her two 180 h.p. Nelseco Diesel-engines, three Delco plants, for pumping salt, cold fresh and hot fresh-water respectively, a Universal electric generating-set for charging the lighting system batteries, Allan-Cunningham air-siren, two Winton 7½ k. w. generating-sets which operate electric deck auxiliaries, bilge pumps and provide current for heating and cooking. A new launch is being constructed for the EDYTHE which will have a 125 h. p. Hall Scott gasoline-engine.

About the time this appears in print the U. S. Shipping Board motorship, WILLIAM PENN, will be in New York after having made her third voyage. Reports which have been received indicate that her performance on previous voyages will even be exceeded and that she will have more firmly established the standing of the Diesel-drive among American shipowners. She is operated by the Barber Line and is under the command of Capt. R. H. Wright, whose opinion of motorships is expressed in the following excerpt from his report written from Kobe, Japan:—"I have personally noticed that wherever the WILLIAM PENN goes, the former incredulity and doubt as to her ability to make good and stand the test of time have entirely disappeared and a general opinion exists that the Diesel engine has come to stay, an opinion, I venture to add, that I thoroughly agree with."

Capt. Wright's report states that during the first three months of the voyage she averaged 11.42 knots on an average daily fuel-consumption of 13.4 tons. During this period the vessel discharged and loaded two cargoes and entered and cleared thirteen ports, not including the Panama Canal zone. She covered 17,580 nautical-miles during this period and attained as high as 12.06 knots, only once dropping below 10.95 knots. This was when she ran from Hongkong to Foochow Roads in the teeth of a Nor'east monsoon and through a fog, at which time her speed under reduced revolutions was 9.2 knots. Everett N. Edes, her Chief-Engineer, reports that he obtained 2.98 nautical-miles per hour per barrel of fuel-oil consumed, and that for a "steaming" day of 24 hours the consumption was 94.38 barrels of oil, or 13.4 tons.

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Our Readers' Opinion

(The publication of letters does not necessarily imply Editorial endorsement of opinions expressed)

OPERATION OF REDUCTION-GEARED AND OTHER MOTORSHIPS

To the Editor of MOTORSHIP:

In regard to the German motorships HAVELLAND and MUENSTERLAND and also the RHINELAND will say that I visited these ships while in Hong Kong and Manila. The engineers of the HAVELLAND and also the MUNSTERLAND informed me that they had had absolutely no trouble whatever with the high-speed Diesel engines or the reduction gears. These ships maintain a regular schedule along the China coast and apparently have no trouble doing it. Your descriptions in MOTORSHIP of these two ships were so complete that there is no need of me saying much. At the time I was on board these boats the engineers were only doing the regular maintenance work such as examining fuel and exhaust valves, etc.

The twin-screw motorship RHINELAND which has crosshead, slow-speed engines of a new design had a run of bad luck. On her outward bound voyage from Germany the outboard column of No. 6 A-frame of the starboard engine cracked. This put all the strain on the inboard column, consequently it carried away. The engine was stopped before any great damage could be done. First they removed the piston, crosshead and connecting-rod and tried to run it that way but found that there was too much vibration. So they put back the connecting-rod and crosshead, the A-frame being held together by means of four pieces of angle iron. From that time on they had been running on five (5) cylinders on the starboard engine and experienced no further trouble whatever, the ship making a speed of 12 knots. From what the engineer says, I think the A-frame was defective, as they had no trouble with any of the others. As the engines in the RHINELAND are the first of that particular kind that the builders have made there is considerable chance for improvement. Not from their operating standpoint but from the cleanness. As there are no plates on the frames, any oil has a chance to work out, and consequently the job looked pretty dirty to me when I saw it.

A. L. Hinsch, Chief-Engineer, M.S. "Donna Lane" and Robt. Gray, 1st Assistant Engineer

The vessel of which I am chief, the DONNA LANE, has covered to date 27,309 nautical miles at an average speed of a trifle better than 8 knots. The daily fuel-consumption at sea for all purposes averages 32½ barrels. Daily lubricating-oil consumption at sea for the main engines 6 gallons; for the main auxiliary engine 2 gallons.

She is powered with twin 500 s.h.p. McIntosh & Seymour engines. One 37½ h.p. Fairbanks-Morse engine drives all of the auxiliaries such as pumps, steering gear, lights, etc., at sea, with one 25 h.p. engine of the same make for emergencies at sea and for use in port. The power for the deck winches is provided by an oil-fired donkey-boiler.

The motorship "Donna Lane" at Manila, P. I. She is propelled by twin 500 shaft h.p., McIntosh & Seymour Diesel engines

Total time lost for all stops at sea during this period is 3 hours and 48 minutes. This was mostly for minor adjustments on the first part of the voyage. In every case whenever it was necessary to stop an engine we notified the officers on the bridge when we would stop and how long we would be stopped. And in no case did we ever exceed the time. During the last 13,500 miles we had to stop the port engine once for 15 minutes.

On the voyage from Manila to San Francisco (6,535 miles) there were no stops whatever. The greater part of this run we used an oil of 15 degrees Beaumé gravity. We changed four exhaust-valves on this run without stopping the engines while doing it.

I cannot speak too highly of the rest of the engineers. Robert Gray, the first-assistant, Henry Thompson, the second assistant, and Arthur Anderson, the third assistant. It was through their loyalty, co-operation, and ability that we were enabled to make as good a showing as we have. By the way, I forgot to state that the total repair bill to the main and auxiliary engines for this entire period does not exceed $10.00. There were a couple of small bills for electrical repairs that we could not do ourselves, not having the facilities.

A. HINCH.
Chief-Engineer
Motorship DONNA LANE,

FORGED VERSUS BUILT-UP CRANKSHAFTS

To the Editor of MOTORSHIP:

In the February issue of your paper Mr. D. M. Shannon expresses preference for the solid shaft. In explaining his opinion (which seems in controversy with the practical experience of leading firms) he states that the only reason why the forged shafts have failed is through being too highly stressed. As, moreover, the forged shafts now are manufactured with a greater approach to uniformity and, on the other hand, the built-up shaft bears great shrinkage stresses, Mr. Shannon thinks the forged system is the better one.

It has to be agreed that solid shafts will be safer as far as homogeneousness has been approached in manufacturing, but still I think that the built-up shaft will be the safer, even when a completely homogeneous forged crank shaft can be produced.

Apart from other considerations I believe that the shrinkage fit of the built-up shaft is to be considered a guard against dangerous vibrational and other torsional forces. A torsional knock that is sufficient to break a solid shaft will *cause a slight shifting* in the shrinkage fit of the built-up shaft, saving the journals and webs. So the built-up shaft will stand the trial where a solid one gives out.

As to the influence of the initial shrinkage stresses, it may be remarked that these stresses are known and are taken into account when fixing the dimensions of the webs. Enlarging these dimensions to the extent required for a sufficient load margin will only add to the weight of the engine. When, however, the diameter of journals has to be enlarged (which is necessary with a solid shaft to meet the load maxima) the engine friction losses will be greater.

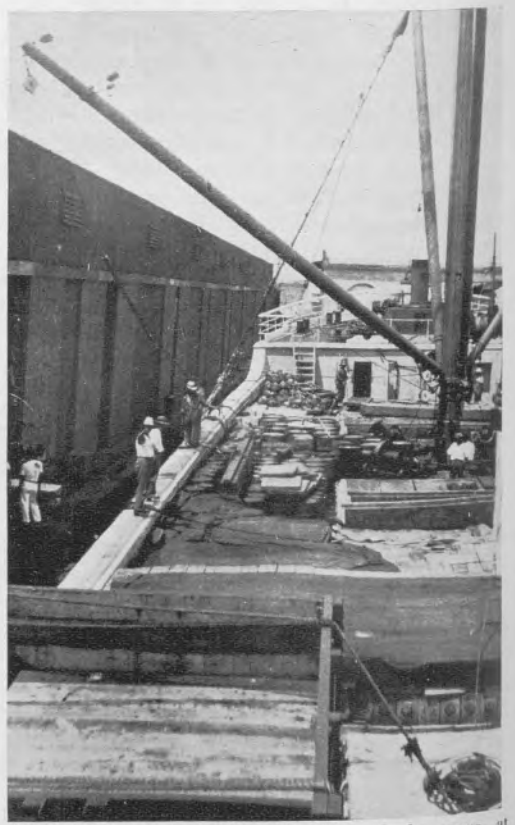
S. SNUYFF.
Zandvoort, Holland.

RECOVERY OF HEAT FROM EXHAUST GASES

To the Editor of MOTORSHIP:

In your January issue J. A. Chaloner makes a calculation about the heat con-

(*Continued on page* 361)



M.S. "Donna Lane" unloading deck cargo at Manila, P. I.

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tained in the exhaust of Diesel engines with the result that he states it will be 3.275 B. Th. U./B.H.P.-hr. He further assumes that of this heat 1,650 B. Th. U./B.H.P.-hr is available, "allowing for volumetric efficiency and a reasonable temperature of the exhaust gases on leaving the waste heat boiler." This would mean that the exhaust heat boiler would have an efficiency of about 50 per cent.

Immediately, however, this supposition is followed by the information that *the exhaust-heat boiler has an efficiency of* 60 *per cent* and now the heat available for steam raising is computed to be 60 per cent of 1,650 B. Th. U. or 990 B. Th. U./B.H.P.-hr.

Has Mr. Chaloner counted the boiler losses twice? Or has the first heat loss of 50 per cent a bearing on other losses (e.g., in the cooled exhaust manifold)? In the latter case what have these losses to do with the "temperature of the exhaust gases after leaving the waste heat boiler"?

Perhaps Mr. Chaloner will kindly explain these points.

Another matter on which I cannot well agree with Mr. Chaloner is that additional advantage would be gained by using jacket-water heat for feed-water heating. The heat contents of the gases after leaving the steam-raising and superheating parts of the boiler are more than ample for heating the feed-water to the boiling point. So I think it would not pay to give the cooling jackets the function of an economizer, except in cases where the heat from the exhaust gases leaving the boiler may be used for such other purposes as evaporating, bathing, washing, laundry, cooking, cabin heating, etc. In big plants, however, it seems preferable to have an economizer heated with the exhaust gases from the exhaust heat boiler. The gases, after leaving the economizer, will still contain some 15 per cent of the original fuel heat, being in a plant of 12,000 B.H.P. about 12,000,000 B. Th. U. per hour, which, in moderate climates will be sufficient for all household purposes, even when a swimming bath is provided.

If I am well informed, in the Still engine the jacket now is not used for feed heating but for *steam raising,* which is quite another case. In the Still engine this is important because the 2-stroke principle is used and the exhaust-belts present great cooling surfaces (or rather heating surfaces in the case of using them as steam raising means).

Making use of the heat from the jacket and cylinder head for steam raising in four-cycle engines would certainly not be impossible, and possibly it would give more advantage than using it for feed heating.

S. SNUYFF.

Zandvoort, Holland.

To the Editor of MOTORSHIP:

UTILIZATION OF EXHAUST GASES

The interesting letter from Mr. S. Snuyff of Zandvoort, Holland, which appeared in your issue for February under the title of "The Utilization of Exhaust Gases," utilizes for the basis of his calculations the trial results of the Still Marine Unit built by Scotts' Shipbuilding & Engineering Co., Ltd., of Greenock, and once again falls into an error which, in my experience, appears rather prevalent. I hope that this attempt on my part to clear up the misapprehension may appeal to you as likely to interest the far-flung circle of your readers.

Mr. Snuyff quotes a trial which was selected for reproduction in your article in April, 1922, page 273, but has made a slight slip in deducing his figures for steam horsepower "on an I.H.P. basis."

With a total I.H.P. of 391, built up from a combustion M.E.P. of 80.5 lbs. per square inch, plus two steam M.E.P.s totaling 9.81 lbs. per square inch "referred" to the combustion piston swept volume, the combustion I.H.P. is 348.5 and the steam I.H.P. is 42.5, not 36, as given by Mr. Snuyff by some calculation not quite apparent.

I have not the actual steam production figures of this particular trial in front of me, but a very similar trial gave 807 lbs. per hour, so that the 800 lbs. per hour quoted may be taken as correct, and this gives a steam consumption of $800 \div 42.5 = 18.9$ lbs. per I.H.P. Now—and this is my first point—since every engine must have mechanical losses, and these have to be met before useful power can be available, they may be fairly debited to the ordinary combustion side of the Still Engine, and the steam I.H.P. considered as B.H.P. with 100% mechanical efficiency. (Equally, of course, the mechanical losses may be allocated in proportion to the two systems; but the above is the simplest way to consider the matter.)

This, then, gives a steam consumption of 18.9 lbs. per *Brake H.P. of profit* and though high enough is not unreasonable, especially if it be remembered that the H.P. steam was expanded in a small (14" bore by 22" stroke) cylinder, added only for purposes of trials, and that the L.P. steam only was expanded in the Still cylinder, where it received the benefit of the system, namely, it absorbed heat from the combustion side during expansion.

In the sea-going sets now being erected at Messrs. Scotts' Yard, all the steam will be expanded in the four Still cylinders (all similar), one taking H.P. steam and compounding into the remaining three as L.P. on the steam side. The steam thus operates under better conditions than in any known steam engine, turbines not excluded.

My next point is in reply to the last paragraph of Mr. Snuyff's letter:

Mr. Snuyff has apparently forgotten that the jackets of Still engines are in water circuit with the boiler and recover a large percentage (normally wasted) of the original fuel heat. The jackets in fact form a boiler of 100% efficiency, from which has to be deducted only the small external radiation losses (air leaks, etc., are in the nature of things impossible), and this, combined with a reasonable boiler efficiency for the recovery of exhaust gas heat, accounts for the perfectly correct *average* result of 80-87% that he arrives at.

The above figures are all extracted from fully authenticated trials of Scotts' *two-stroke* Still engine, and Mr. Snuyff will realize the large part that the jackets play in earning the dividend if he does not overlook the cooling effect of the scavenge air on the exhaust gases when he compares it with his four-cycle engine figures.

H. A. D. ACLAND,
A. M. Inst. C. E.
A. M. I. Mech. E.

The Still Engine Company, Limited,
7 Princess Street, Westminster,
London, S. W. 1, England.

COMPRESSED-AIR FOR AUXILIARIES

To the Editor of MOTORSHIP:

I am quite interested to read in your February number that the Dutch motorship RHEA, fitted with Werkspoor engines, has her steering engine driven by the exhaust gases. I presume you mean the heat of the exhaust gases is used to make sufficient steam in a donkey boiler, or possibly they may heat up a sufficient quantity of low-compressed air to do this. This latter method would, I think, prove the simpler.

It is well to remember the following statement made, I think, by Mr. Reavell before the Institute of Marine Engineers, March 22nd, 1921, when discussing Mr. Walter Pollock's paper on "Auxiliary Machinery of Oil-Engined Vessels":

"For a pressure of 20 lbs. at winch (which sufficed in the case he reviewed on a vessel with 5 ton winches to lift one-half ton articles on an average) it would only require one-seventh the power to supply the requisite air as compared with a 100-lb. steam pressure at winch. The principal amount of heat required in the latter case is that to overcome latent heat and produce steam from water. It only takes 2-3% extra to give 100 lbs. pressure.

"They are thus perfectly right in using 100 lbs. pressure with steam, as it costs practically no more than 10 lbs. once they have overcome the latent heat.

"For air, however, every extra pound pressure you demand over the pressure actually required, means so much extra horsepower, which has to be supplied by the prime mover, whether a steam, oil or electric motor, to the air compressor supplying the air.

"Leakage losses would be less, only one pipe is required from compressor to winch, and no return or exhaust is needed at all. For occasional heavy lifts, gearing can be fitted to winch, and the 20 lbs. pressure would suffice at a slower lifting speed."

By making use of a suitable air heater we can increase the energy in a given amount of air, and moreover will find the steering engine, or such like, will need less lubrication and have no condensation bothers, if one arranges suitable cut-offs. The increased efficiency will be very marked indeed.

I notice in an account of some experiments made in the University of Illinois lately with air-reheaters that air at 400 deg. Fahr. will yield the same B.H.P. with two-thirds the compressor capacity and steam consumption required when the air is used at 100 deg. Fahr. Cut off at about one-fourth stroke proved to give the best results in these tests.

I am convinced if the field of compressed air for auxiliary use of ships were exploited a bit more seriously, very encouraging results could be obtained, while the actual outlay would prove very small, and most of the prejudice among engineers against compressors would soon be overcome.

This system would be a low pressure one, and no leakage in pipes or trouble from the compressor would be likely to occur. At sea this compressor would be direct driven by the main engine. Such an arrangement ought to prove much cheaper than steam or electric power, while it would retain a perfect flexibility. This subject might perhaps produce some interesting contributions in your paper.

W. HAMILTON MARTIN.

Fredk A. Pullen & Co., London, England.

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Our Workboat Forum

TO AID QUICK TURNING

To the Editor of MOTORSHIP:

Perhaps you can help me! My fishing boat is 35′ x 11′ x 3′ 3″ draft and has a 20 h.p. kerosene engine turning a 24″ dia. wheel. The keel is deep and runs back to just in front of the propeller and the model of the boat is pretty full. The rudder is of boiler plate 24″x30″, but the boat will not make short turns. Her keel runs nearly level, that is, the depth just back from the fore-foot or round of the stem is nearly that aft under the propeller. With these figures to help, can you tell me what I can do to make her steer easier?—*E. F. R., Bridgeport, Conn.*

[*The propeller in your boat is undoubtedly suffering from being placed directly back of a big, full-bodied hull which doesn't allow of a sufficiently clear flow of water to the propeller. The thick deadwood and keel in front of the wheel also cuts off much of the flow of water. By cutting an opening in the deadwood so as to leave only a narrow width of keel extending aft from the hull to take the heel of the rudder and the stern post at present fitted, the flow of water to the propeller would be better, permitting more speed. And, the radius of the turn when the helm is put hard-over would be less, also the boat would turn shorter and easier. By stowing the ballast or other movable weights further aft the bow would be raised, which would permit it to swing with the action of the rudder and not retard the turning of the boat as it does now. In our opinion the rudder is large enough.*]

CAPACITY OF SMALL BARGE

To the Editor of MOTORSHIP:

In a recent magazine article I noticed the statement that a freight-boat to carry 40 tons could be built 30 ft. long by 12 ft. 6 in. breadth by 4 ft. loaded draft and that a 12 h.p. oil-engine would drive her 6 knots. This doesn't look right to my untrained eye. Can it be done? I am figuring on building such a craft and desire to avoid mistakes.—F. M. T., Chicago, Ill.

[*No, it cannot be done. If we assume a perfect square-cornered box-shaped craft the displacement of this boat of 30 ft. waterline length, 12 ft. 6 in. w.l. breadth and 4 ft. loaded draft would be 96,000 lbs. The ratio of deadweight to displacement in small barges is about 0.7 to 0.8; on this basis the deadweight would be 67,200 to 76,800 lbs But such a boat would never be built and if it were 12 h.p. could never drive it at 6 knots.*

Assuming for the barge the extremely high block co-efficient of 0.9 of the displacement of the box-shaped hull of 96,000 lbs., the displacement of the fullest model which could be adopted would be about 86,400 lbs. The hull of the barge could not be less than 20 per cent. of the displacement, leaving 80 per cent. of 86,400×0.8=69,120 lbs. as the possible deadweight capacity for such a barge. This is 34.5 tons. However, these capacities are greater than would be common practice and the resulting craft would be exceedingly "boxy" and would require many times 12 h.p. for 6 knots. A 12 h.p. engine would require to turn a large diameter propeller in such a craft, and as such small engines hardly deliver their power at less than 300 r.p.m., we can assume that a propeller of about 30″x30″ would be used, which would not drive the boat at over 4½ knots, as the slip in such an installation would run around 40-50 per cent.]

CHANGE OF FERRY PROPELLER

To the Editor of MOTORSHIP:

We have a ferry in which a 220 h.p. Diesel engine drives a propeller of 4′ 3″ diameter and 3′ 0″ pitch at 300 r.p.m. The blades are 19″. The propeller previously fitted was 5′ 0″ diameter by 4′ 3″ pitch, but the engine could only turn it 200 r.p.m. and we did not get the requisite speed. It seems to us that an intermediate size wheel 4′ 6″ by 3′ 6″ would be better. Would a propeller of these dimensions turn at 300 r.p.m.?—*W. A. H., New York.*

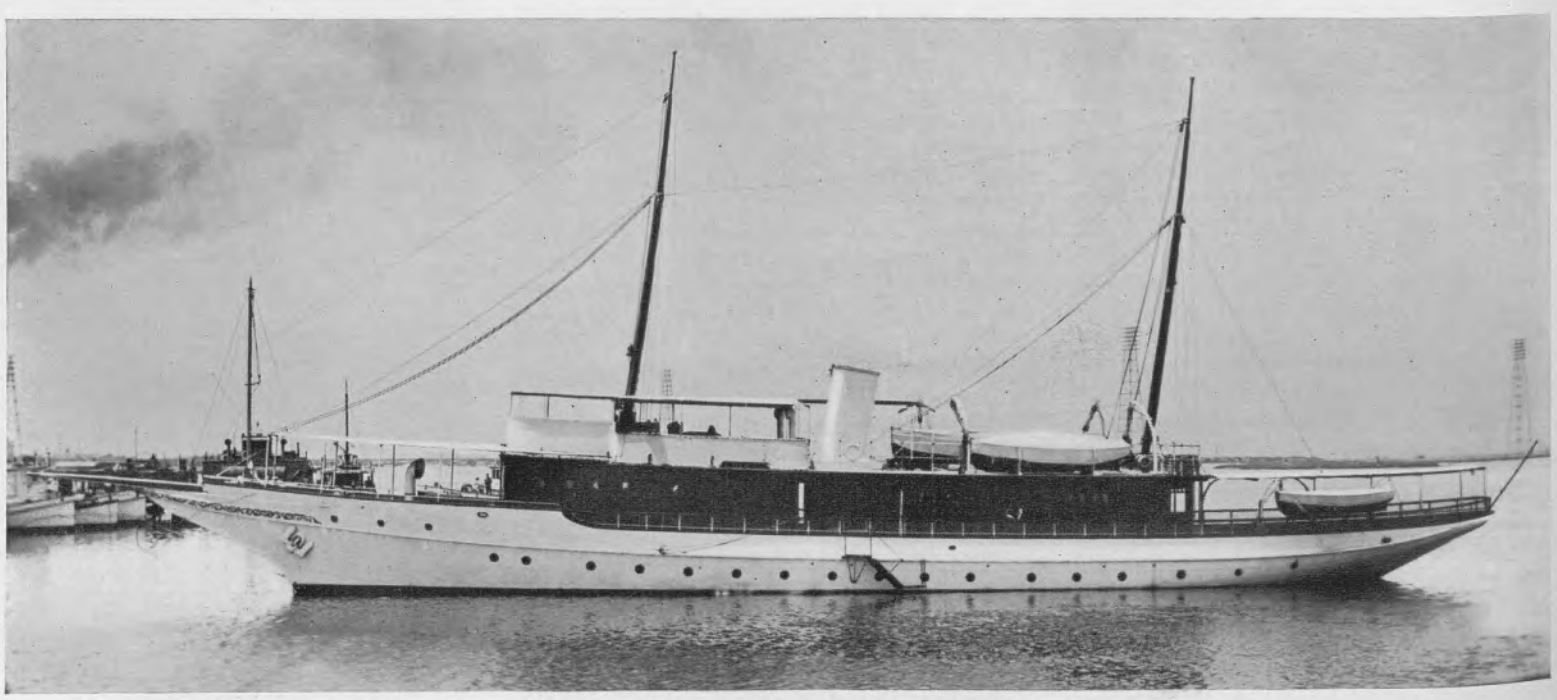
[*It is not absolutely feasible to definitely advise the results of a change of propellers without having before one the lines of the boat and complete data, as the form of the hull, clearance of propeller blade and hull, slip, shape of blade, etc., affect the speed and revolutions. Without such data and assuming that the present 4′ 3″ by 3′ 0″ propeller turns 300 r.p.m. with the 220 b.h.p. engine, we feel that the 4′ 6″ diameter by 3′ 6″ pitch propeller would hardly turn 300 r.p.m. The blade area and diameter would be greater, which would reduce r.p.m., but it is likely that the slip would be reduced and the speed of the boat thereby increased very slightly. There are very intricate problems connected with a double-end ferry-boat installation which cannot be solved without an intimate knowledge of the details.*]

TWIN-SCREW INSTALLATION FOR LAUNCH

To the Editor of MOTORSHIP:

For a 45 ft. by 12 ft. by 3 ft. draft launch for carrying farm produce to the city, and to tow a scow loaded with the same goods, would one oil engine or two be better? I plan to install enough power to drive this boat eight miles an hour loaded and towing the scow.—*A. J. W., Baltimore, Md.*

[*Without more definite data before us on your proposed boat it is impossible to more than approximate the power needed. You do not state the dimensions of the scow and we must therefore infer that she is of maximum size in order to be on the safe side. To propel such a towing and freight boat itself at eight nautical miles an hour in calm, still water would require approximately 25 h.p., and an engine of the Diesel or surface-ignition type probably would turn at 300 to 400 r.p.m. and would require a propeller of about 30″ diameter. Unless the bottom of the boat aft over the propeller were flat, or had a tunnel to permit of a larger diameter wheel being fitted, 30″ is about as large a wheel diameter as will fit the draft. As your boat must face usual conditions on Chesapeake Bay it would be best to have a hull with moderate "deadrise" or angle of bottom of the boat rather than flat bottom, and fit two propellers to come within the 30″ allowance. Therefore, we would recommend two 20 to 25 h.p. oil-engines to provide a speed with heavy tow against average tide and wind and to come within 36″ draft.*]



M. Y. "Edythe," George Whittell, Jr., owner, powered with two 180 h.p. Nelseco Diesel-engines. She is the largest motor-yacht on our Pacific Coast

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German Oil-Engines for Merchant Ships*

By Professor Walter Mentz, Technische Hochschule, Danzig

IN the fall of last year the author made a visit to all the large German works where oil engines are built, for the purpose of studying the latest developments in modern Diesel engine practice. This article embodies his observations on the building of oil engines for merchant ships for the benefit of those who, through lack of time or opportunity, are unable to undertake such a journey as the author made. Much that the author saw or heard must remain unpublished or only hinted at, either because of pending patents or on account of experiments not yet concluded. For example, there are already on the test bed or in the shops in different works smaller or medium size Diesel-engines with airless injection, operating absolutely without smoke. The cooling effect of the expanding air is not present, and the result is a smaller fuel consumption and bigger horsepower for a given cylinder diameter and stroke. The engines are thereby rendered simpler, lighter and cheaper.

In this article a general survey of the modern principles of construction will first be given, with a criticism of modern practice, and thereafter a description of the particular designs of the different firms.

These firms are, in alphabetical order, the following:

1. Maschinenfabrik Augsburg-Nürnberg, in Augsburg.

That the German U-boat engines had reached a very high degree of efficiency and reliability is well known, but it is not so well known that the German engines now being built for merchant vessels can with full honors be placed side by side with the U-boat engines. This will become much plainer as the airless injection type comes more to the forefront.

In order to avoid repetition and to give a comparison, the chief dimensions of all the engines under discussion are given in a table herewith. It will be noticed that the modern engines show a greater uniformity as compared with those built in the years before the war. This is of course an improvement and shows that a certain clearness of view has now been reached. It will be explained later, when describing the Sulzer-engine itself, why the two-cycle engine which before the war was the leading type for German motorships and in which much confidence was placed, at the present moment is relegated into the background. In the four-cycle engine a clear coincidence is already noticeable with regard to the output, number of cylinders and piston speeds.

It is also interesting to compare in this table compared with earlier designs, that is to build engines with as long a stroke as possible, although the ratio of stroke to cylinder diameter = 2, as used by a British firm, has not yet been reached in Germany.

It is peculiar that no Junkers engine has been built in Germany for some years, because great expectations were held of this type before the war. When he had perfected his experimental double-piston engine, Professor Junkers had made an agreement with 6 German and 4 foreign firms, to develop the system with him through experiments on the one hand and series-production on the other hand. A particularly close co-operation has always been maintained between Professor Junkers and the English firm William Doxford and Sons Ltd. in Sunderland; and this connection still exists. Before building bigger engines Doxford's first designed a single-cylinder engine for the purpose of making exacting experiments in the works. When the co-operation between Professor Junkers and the foreign firms was interrupted by the war, the above mentioned firm was able to continue the development of the system alone, and is the only firm which has obtained real results with the Junkers system. They have for some time had three single-screw ships, each with a 3000 b.h.p. engine, successfully running in continuous service. These engines are noteworthy for their fine regulat-

Calculated s. h. p.	No. of cyl.	s. h. p. per cyl.	Diam. inches	Stroke inches	Revolutions	Ratio Stroke diam.	M. E. P. lbs.per sq. in.	Piston Speed ft./min.	Type	Builder	Remarks
					I—GERMAN ENGINES:						
1600	4	400	26.77	43.31	85	1.62	75.52	614	Two-cycle	Gebr. Sulzer	Tanker
2500	6	416	26.77	47.25	80	1.77	76.52	631	Two-cycle	Gebr. Sulzer	North German Lloyd
180	3	60	13.78	15.75	300	1.14	66.66	787	Four-cycle	Deutsche Werke, Kiel	Driving Compressor
300	6	50	12.60	17.72	250	1.40	70.83	738	Four-cycle	W. & M. Fabrik Görlitz	.....
350	4	87.5	15.75	21.65	240	1.375	67.56	866	Four-cycle	Krupp-Germaniawerft	For sailing ship
950	6	158	21.65	35.43	135	1.64	70.12	798	Four-cycle	Deutsche Werke, Kiel	Tanker
1000	6	167	22.84	32.28	140	1.41	70.26	754	Four-cycle	W. & M. Fabrik Görlitz	.....
1400	6	234	25.59	39.37	125	1.54	72.54	829	Four-cycle	Krupp-Germaniawerft	.....
1600	6	267	27.17	39.37	120	1.45	76.24	787	Four-cycle	M. M. Werke vorm. Benz.	.....
1600	6	267	27.56	47.25	100	1.72	73.96	787	Four-cycle	M. A. N.	North German Lloyd
1250	6	292	28.35	51.18	95	1.81	74.39	812	Four-cycle	Blohm & Voss	Rheinland, Ermland
1250	6	292	29.53	47.25	100	1.60	70.55	787	Four-cycle	Deutsche Werke, Kiel	.....
1800	6	300	28.74	49.21	100	1.71	70.12	861	Four-cycle	Vulkanwerke	Single-screw ship
1850	6	308	29.53	45.28	110	1.53	70.55	832	Four-cycle	Krupp-Germaniawerft	.....
					II—BRITISH AND DUTCH ENGINES:						
1050	6	175	22.0	39.37	125	1.79	72.68	821	Four-cycle	Werkspoor	.....
1250	6	208	24½	39	118	1.59	75.00	768	Four-cycle	Vickers	.....
1750*	8	219	26½	47	96	1.77	68.98	750	Four-cycle	North British Diesel Engine Works	.....
2400†	8	300	29⅛	45¼	110	1.55	70.69	832	Four-cycle	Harland & Wolff	.....
2600	4	650	22¾	2x45⅝	77	2.00	90.00	586	Four-cycle	Doxford & Sons	.....

* 2330 i. h. p. (mechanical efficiency asumed to be 0.75) † 3200 i. h. p. (mechanical efficiency assumed to be 0.75)

2. Schiffswerft und Maschinenfabrik Blohm & Voss, in Hamburg.
3. Deutsche Werke, in Kiel.
4. Motorenfabrik Deutz, in Cologne-Deutz.
5. Waggon-und Maschinenbau-A. G. Görlitz, in Görlitz.
6. Friedr. Krupp Germaniawerft, in Kiel-Gaarden.
7. Mannheimer Motorenwerke vorm. Benz & Cie, in Mannheim.
8. Maschinenfabrik Gebr. Sulzer, in Ludwigshafen a.Rh.
9. Schiffswert und Maschinenfabrik Vulkanwerke, in Hamburg.
10. A.-G. Weser, in Bremen.

There are, of course, other firms, building oil engines for ships, of which the most notable example is the Deutsche Werft in Hamburg which together with the Allgemeine Elektrizitäts-Gesellschart in Berlin has incorporated the "Deutsche Olmaschinengescellschaft." This firm builds its engines under license from Burmeister & Wain in Copenhagen and has now orders for 11 large motorships, among them the two biggest in the world, each of 21,000 tons.

There are today, compared with the years before the war, few firms in Germany building oil engines for ships. The reason for this is the comparatively small number of merchant vessels at the present moment being built in Germany and the cessation of the construction of warships.

* Issued simultaneously in MOTORSHIP and WERFT, REEDEREI, HAFEN, Berlin, by arrangement.

the German engines with the British and Dutch engines, the values for which have been taken from articles in the ENGINEER 1921, page 633 and following. The comparison shows that about the same constructional values are used in Germany as abroad. In the table are to be found three smaller engines from 180 to 350 h.p., designed as auxiliary motors for sailing ships or for the driving of auxiliary machinery, and which therefore are built without crossheads.

All the other four-cycle engines are designed with crossheads and are mostly from 1400 to 1800 b.h.p. Most of the different firms use a piston speed of about 790 ft. per min. A higher piston speed is thus chosen as compared with marine steam engines which on an average use piston speeds of between 630 and 750 ft. per min. The reason for this is that the four-cycle engine is a typical high speed engine, whereas the two-cycle type is adapted to a somewhat slower speed. The revolutions of the four-cycle engines have been reduced to 100 or more as compared with the higher-speed designs before the war.

This number of revolutions (also somewhat higher than is usual in marine steam practice) is allowable because the engines are mostly used for twin-screw ships. The number of revolutions is also well adapted for the propellers themselves. Should in the future, which is probable, a greater number of motorships with single screw be built, then undoubtedly the number of revolutions will be still further reduced, because the single screw would otherwise have an unfavorable ratio of pitch to diameter. A tendency is shown in all new designs to choose the biggest possible ratio of stroke to diameter as ing capacity (they can be regulated down to 17 revolutions) and for their good mechanical efficiency. To this must be added of course the other advantages of the Doxford engine, such for example as the reduction of the compression to about 300 lbs. per square inch and the airless injection.

The Cammellaird-Fullagar design, which in reality is only a modified Junkers design with two instead of six cranks per pair of cylinders, has also proved so successful that this type, like the Doxford model, is about to be built in greater numbers. This proves that it is not the fault of the Junkers design itself that it has met with so little success in Germany. The last word, however, has yet to be said with regard to this system. The engines which Professor Junkers now is building in his own works on an improved system can only be described later.

As regards the types now being built in Germany, the following can be said: The only design taken into consideration when the four-cycle type is used as a propelling engine is the six cylinder type. This number of cylinders is, of course, necessary for the four-cycle engine in order to obtain reliable starting conditions, that is, if one gets away from the earlier common but complicated system of changing over from four-cycle to two-cycle at the start. Changing over from compressed air to oil usually takes place in two groups, in such manner that first three cylinders are changed over from air to oil and then the other three.

Nowadays the closed type engine is the only one, whilst the endeavor before the war went

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in the direction of producing a type of marine engine which was open for oiling and for inspection of the bearings. This closed type is necessary in order to catch the oil particles whirled about by the forced lubrication and to avoid the unpleasant results caused by the vapor of lubricating oil in the engine room.

There exists a certain difference of opinion as to which arrangement of the frames is to be preferred, namely if a frame is either to be placed in line with the connecting rod axis, or if so-called A-frames are to be placed right and left of this axis. These A-frames can then eventually be relieved of load by the help of tie-rods. The latter design, that is the use of A-frames sidewise to the connecting rod, becomes more and more popular, and will probably in the future be the only design in use and in particular in conjunction with tie-bars. It is not necessary when using these bars to rely so much on the quality of the material of the frames, and a lighter engine is also obtained by this design. The usual double-T-section of the narrow frames placed sideways to the connecting rod axis is lighter compared with the type of frames placed in line with the connecting rod axis, the castings and the controlling of the thickness of the latter becomes less difficult, one obtains also a more reliable and at the same time lighter engine. The engine becomes namely narrower, because it is not necessary to spread the frames so much at the base on account of the connecting rod and crankshaft. The lower breadth of the engine is, expressed in numbers, 3.6 times the cylinder diameter in engines with the frames arranged sideways to the connecting rod axis as compared with 5 times the cylinder diameter in engines with frames arranged at the front and back of the connecting rod axis. These measurements are taken from existing engines horizontally through the center of the crankshaft. By use of A-frames is therefore obtained a narrower, lighter and cheaper engine, with rigidity however answering all requirements. The covering in of the frames can also be easily suited to the side-frame, for plates can here be used in a simple and cheap fashion, giving at the same time easy access to the inner parts of the engine as shown by the following illustrations of finished engines.

Usually the driving gear for the camshaft is placed in the center of the engine, that is between the blocks of the first three and last three cylinders. The helical gear-wheels which earlier were common have now disappeared, because it was impossible to keep them in working order with the means at hand on board ship. The camshaft driving gear is in modern practice the following: a spur wheel on the crankshaft drives a short auxiliary shaft arranged above or sideways to the crankshaft, and the camshaft driven from the auxiliary shaft either by means of connecting rods or by bevel wheels mounted on a quite or nearly perpendicular shaft. In the German designs the camshaft is placed in line with the top of the cylinders. Usually in bigger marine steam engines, in order to provide for the expansion of each cylinder without hindrance, each cylinder is mounted separately and only the upper parts of the frames are connected with another. In oil engines, an the contrary, where cylinder cooling always is used and where all cylinders expand equally, and where further a stiff engine is desirable on account of the valve gearing, it has become usual either to bolt the six separate cylinders together or to cast three cylinder casings in one piece and then connect two such blocks stiffly with another by means of big flanges.

Cylinder covers today in Germany are always made separately from the liners as opposed to several earlier German and a few modern foreign designs. The cooling of the different casings for the valves in the cylinder cover is in general improved, as is also the cooling of the uppermost side of the cylinder cover, as for example in the M. A. N. patented horizontal wall dividing the cover in two parts.

According to the table the greatest cylinder diameter which has been made is 29½ inches, which corresponds to a six cylinder engine of 2000 b.h.p. with moderate revolutions. There is yet nothing that indicates a trend to the double-acting engine, because modern ships are not designed for high speeds and there is no difficulty in building twin-screw ships when the output demands it. The output can also easily be increased without augmenting the cylinder diameter, which of course also is possible, by increasing the ratio of stroke to diameter and further in the four-cycle type by delivering the combustion air under a small extra-pressure.

Two-cycle engines for higher outputs than 2,000 b.h.p. can be constructed without difficulty, as these engines have a smaller cylinder diameter for the same horsepower than the four-cycle, and there is also presented the advantage that the required combustion air can be delivered by a separately driven blower. The two-stroke engine may, not counting the saving of space and weight, for these reasons find further applications for such large powers as are not so easily reached by the more common four-cycle engine.

The channel for compressed air leading to the starting valve is in modern practice no longer built into the cylinder cover, but is arranged on top of the removable cage of the starting valve itself, in order that possible explosions in these pipes caused by vapor from the lubricating oil shall not destroy the cylinder cover itself. The safety valve in each cylinder cover serves in the stop position of the engine also for reducing the pressure in the cylinder to the required value; such a reduction is however held by some to be unnecessary.

For cooling of pistons the system of salt water flowing through telescopic pipes is favored because the system using links easily becomes leaky on account of the sandy water met with at harbor entrances. Leakage through the telescopic pipes is made practically impossible through a special arrangement of the pipes without stuffing boxes.

For the lubrication of the main bearings, connecting rods, etc., oil under pressure is most commonly employed, supplied by a small pump or taken from a tank arranged about 30 feet above the engine. Many firms prefer to introduce the oil into the main bearings from underneath, in order not to have to dismount any oil piping when removing the bearing covers. The required oil pressure amounts in this case to about 21 lbs. per sq. inch. as compared with the earlier value of about 14.22 lbs. per sq. inch. The especially important lubrication under high pressure of the crosshead-pins for the two-stroke engine is described under the "Sulzer"-engine.

Lubricating oil, cooling water, etc., are mostly arranged visible to the eye at outlet from the engine, so that possible interruptions will be noticed at once.

Crankshafts of six-cylinder engines are mostly made in two sections which are then connected by means of a coupling. It is, of course, taken into consideration that only one-half of the shaft is necessary as a spare shaft. In order to neutralize the effect of the moving masses, one-half of the shaft is made the reverse of the other. There still exist isolated examples, however, where the two halves of the crankshaft are made equal to another.

Compressors are without exception built with three stages and placed in front of the engine, coupled to a crank, or two or three smaller compressors are placed at the side of the engine and driven through levers in order to save space.

Suction air can be taken from the engine room

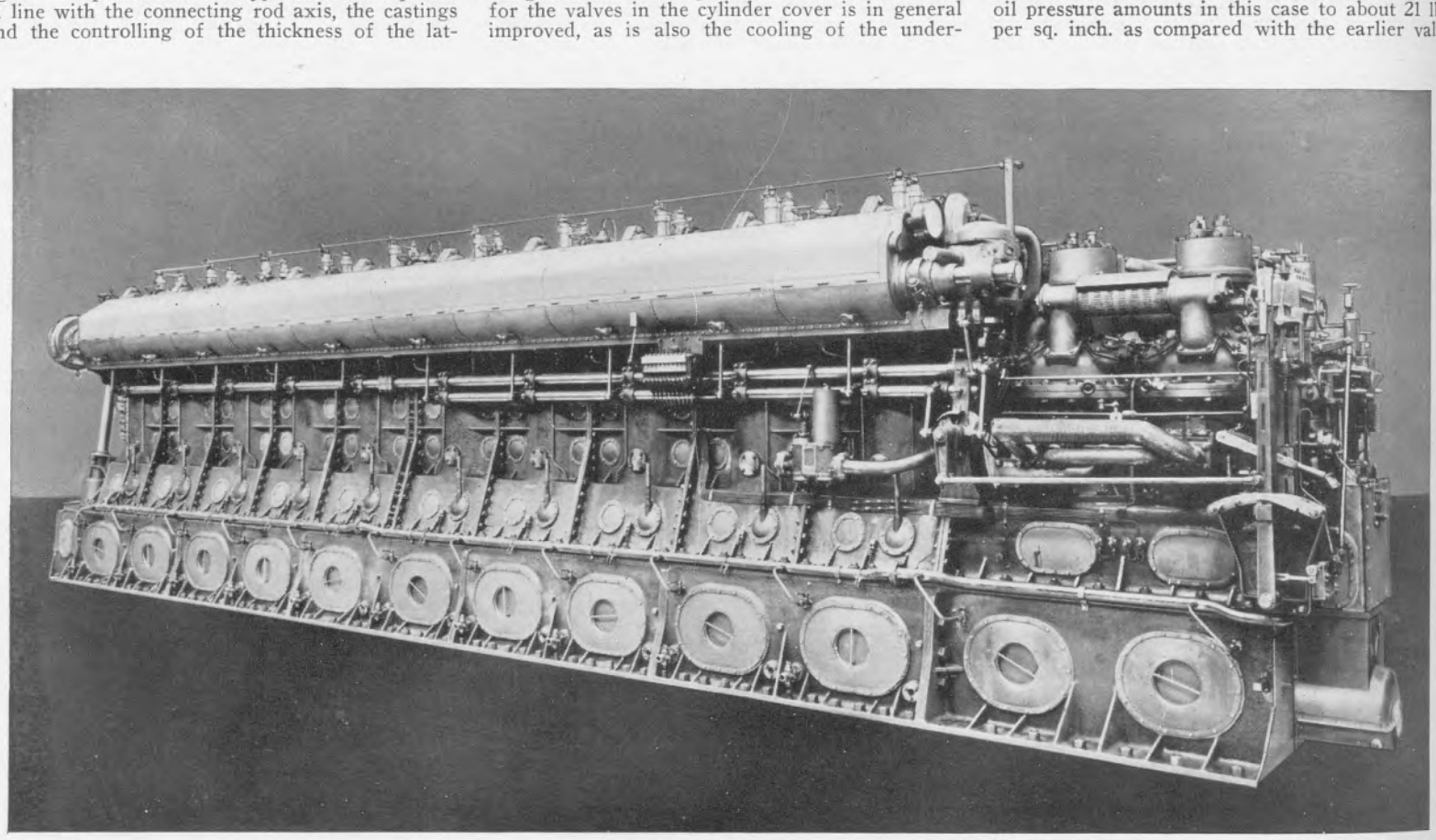

Fig. 1.—3,000 b.h.p. 10-cylinder Augsburg four-cycle submarine type oil-engine

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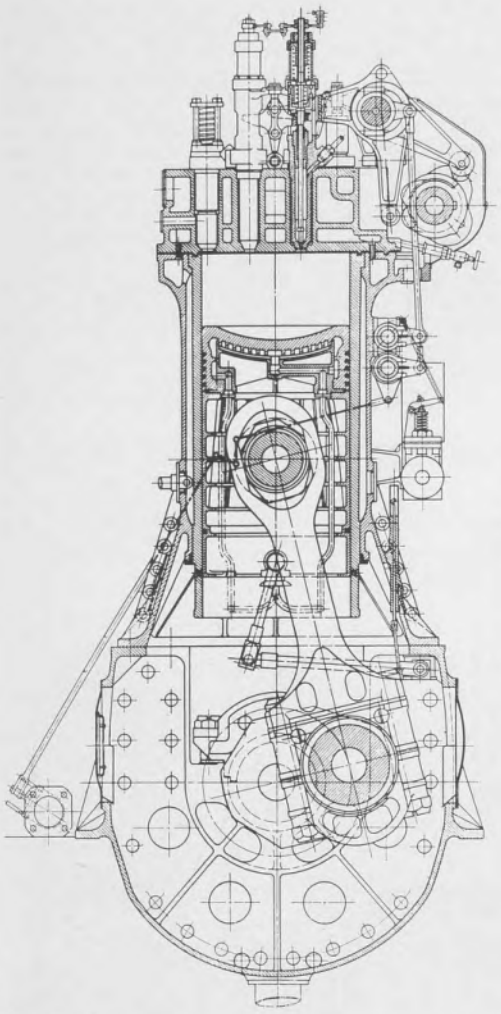
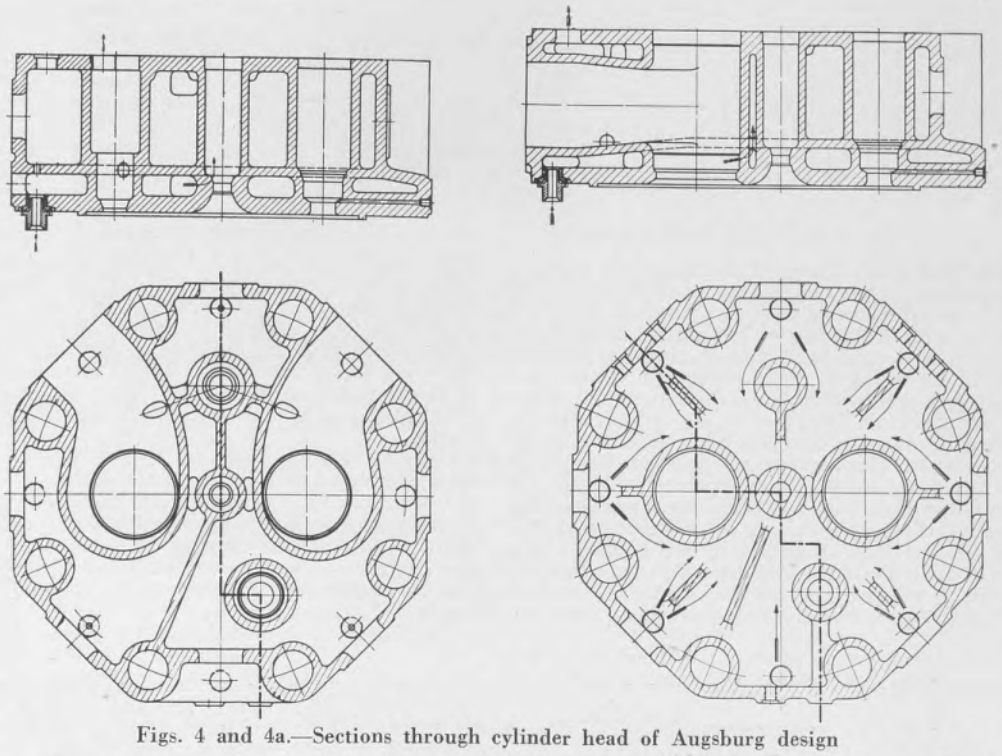


Fig. 2.—Cross section through cylinder of 3,000 b.h.p. Augsburg engine

itself or through special piping from the atmosphere which is especially recommended in winter in order not to reduce unnecessarily the temperature of the engine room.

Fuel pumps in modern practice operate at the same number of revolutions as the crankshaft even for four-cycle engines; they act twice during each cycle of work. One must therefore arrange that the delivery of the pump shall not coincide in any cylinder with the period of injection, which is easy to arrange in six-cylinder engines. The pumps can be made smaller in size through acting twice during two revolutions and they are also easier to operate from the auxiliary shaft as compared with the earlier driving from the camshaft, whilst additionally they can be located within watch of the engineer's stand. The working pistons of the fuel pumps are ground to fit in the casing and have no stuffing boxes.



Figs. 4 and 4a.—Sections through cylinder head of Augsburg design

Reversing of the four-cycle engines usually is arranged through displacement of the camshaft. The rollers of the valve levers must of course first be lifted from the cams and subsequently be replaced on their respective cams. In going over from air-starting to power the use of eccentric bearings for the rocker levers is employed as in stationary Diesel engine practice. The reversing mechanism is interlocked in such a manner that no error of operation can take place. Starting can, for example, only take place when the camshaft really is in an end position, that is when the forward or aft cams are all in their correct positions.

Usually the thrust-bearing is of the single collar type.

Electric power is favored for the auxiliary machinery, especially for the windlasses and the steering engine. The current is obtained from two, or better from three, smaller dynamos driven by Dieselmotors, one of which is able to supply the required current when at sea.

The peculiarities of the different types of engines will be discussed in the following.

Maschinenfabrik Augsburg-Nürnberg (M. A. N.) Augsburg Works

This firm, the classic parent of the Diesel-engine, used to build four-cycle engines for the German navy in their Augsburg works, and two-cycle engines in Nuremburg. Since the war Diesel engines are only being built in Augsburg and the only type being built there today, as it has always been, is the four-cycle; experiments relating to further developments of the two-cycle type are, however, also being carried out.

Most of the high-speed engines on the U-boats were made by the M. A. N. The last type of these engines had an output of 3,000 s.h.p. with ten cylinders of 20.87 inches diameter and stroke and 390 revolutions. This horsepower had hitherto not been attained by any other firm. Two such Diesel-engines built by M. A. N. during the war have been installed by the shipyard of Blohm & Voss in the two motorships Havelland and Münsterland, built by the latter firm. These motors are used with reduced revolutions and lower pressure, and with a reduction gear which cuts down the propeller revolutions to 85. The cylinder jackets of these U-boat engines are made of thin cast-steel in order to save weight. As shown in Fig. 1, the cylinder jackets are connected by flanges at the top, so that a particularly rigid engine is obtained. In the cross section through the engine, Fig. 2, is to be seen a horizontal wall which divides the cylinder cover in two parts, so that the cooling water must first flow over the lower wall. This wall is a M. A. N. patent which greatly improves the cylinder cover. This construction will be later explained with the help of figs. 4 and 4a.

Since taking up the building of oil engines for merchant ships, the M. A. N. has produced a 1,600 s.h.p. set which has already been described in detail in the October number, 1922, of Motorship. Here, therefore, are given only some hitherto unpublished drawings and photographs and

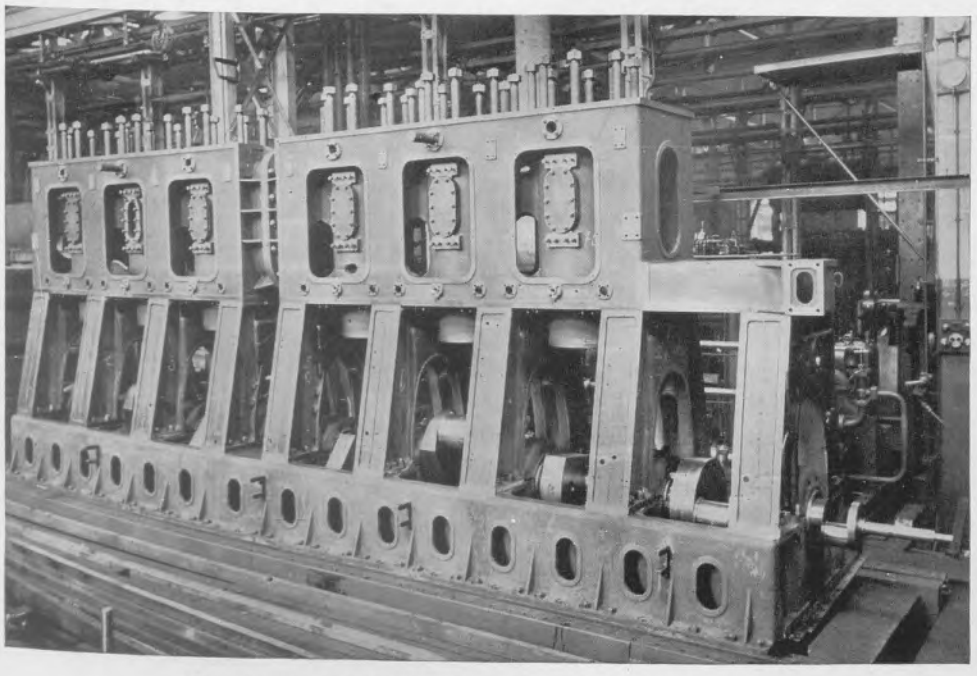


Fig. 3.—Framing of 900 b.h.p. Augsburg marine engine

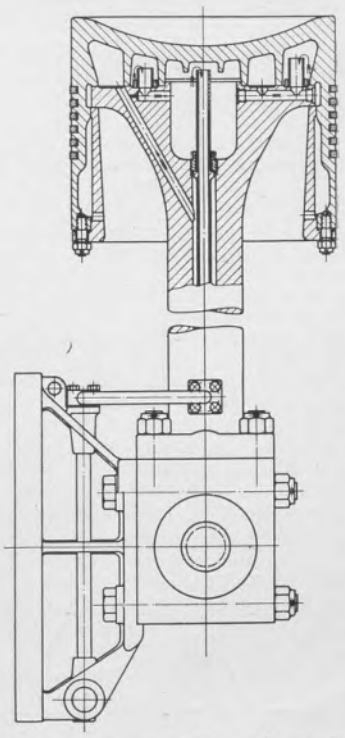


Fig. 5.—Augsburg piston and crosshead

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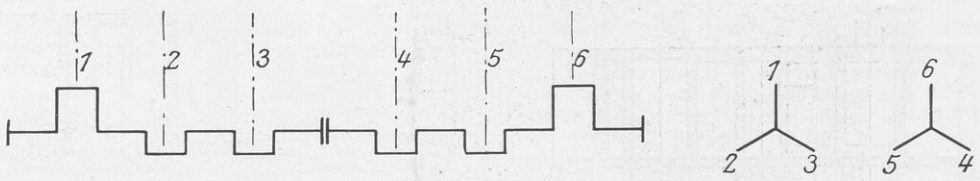

Fig. 6.—Crank angles of Augsburg 1,600 b.h.p. engine

some points are discussed that have not yet been mentioned at all or only partly described.

Each cylinder rests on two frames, arranged in line with the connecting rod axis. The M. A. N. uses also the type of frames described as the best in the beginning of this article, namely the two-footed A-frame with double-T-section, placed opposite the main bearings, see fig. 3 which shows the erection of a new 900 b.h.p. engine without crossheads. This arrangement will very likely also be preferred in the future by the M. A. N. In the last-named engine one sees an example of the casting of three cylinders in one piece with the two blocks then connected by big flanges. The tie rods in the frames which chiefly take up the working pressure are not seen in the illustration because they were not fitted when the picture was taken.

A vertical section through the chambers of the safety valve, fuel valve and starting valve, is shown in Fig 4, with a horizontal section through the suction and the exhaust passages. Two already published sections through the cylinder cover are given in fig. 4a, in order to clearly illustrate this important casting. The middle horizontal wall of the cylinder cover which has already been mentioned above, forces the cooling water, which otherwise would spread around the whole of the space in the cylinder cover, in the direction shown by the arrow, firstly through the lower narrow part of the cooling space and directly in contact with the lower wall of the cover which thus is well cooled. The safety and life of the cover is thus increased in a simple manner.

The piston-rod and the patented piston are connected in a new and peculiar way, Fig. 5. A long sleeve is bolted on to the bottom of the piston in order to make this joint particularly "elastic" against effects due to heat and power, and rendering the bolts easy to get at. This sleeve connects the flange of the piston-rod with the piston bottom. The very thick flange on the piston to which the flange of the piston-rod otherwise is bolted is not necessary with this design. Stresses in the cast iron which could endanger the piston can now not so easily appear; the bolts can also not give out owing to the piston expanding unevenly due to heat. The pistons are oil-cooled in this engine, and the oil must come into contact with *all* parts of the piston as shown by the arrows.

One-half of the crankshaft for the 1,600 h.p. type is the reverse of the other half (see fig. 6); the forces due to the moving masses are therefore neutralized. The order of ignition is in the one engine 1 4 2 6 3 5, and 1 5 3 6 2 4 for the other, which revolves in the opposite direction.

This engine is provided firstly with a regulator for the injection air which operates in correspondence to the quantity of fuel required by the fuel pumps, and secondly with the well-known M. A. N.-regulator by means of which the stroke of the needle valve can be varied. The fuel is injected by this method during the same angle at reduced speed as at full speed. A saving of injection air is thus derived by lessening the area opened by the needle valve.

The Norddeutscher Lloyd, the purchaser of the engine, has specified that it shall also be able to run on tar-oil, and it has therefore been fitted with special pumps for ignition oil and has been severely tested on this oil. The pumps for ignition oil also work when gas-oil is being used.

The overall length of the engine from the fore end of the first main bearing to the aft end of the last main bearing, exclusive of the thrust bearing, amounts to about 35 ft.

BLOHM & VOSS, Kommanditgesellschaft auf Aktien in Hamburg.

This shipyard and engine works has, as is known, built the two motorships HAVELLAND and MÜNSTERLAND for the Hamburg-Amerika Line. In each of these ships are installed two ten-cylinder U-boat motors built by the M. A. N. during the war. These motors produce 1,650 b.h.p. when working at reduced revolutions and pressure, and drive the propellers through reduction gear with a ratio of 2.7 to 1 and down to about 85 revolutions. The advantage of this system over the direct drive consists in greater saving of space and weight which increases the carrying capacity of the ship and reduces the first cost. It was shown on the trial trip by means of a Frahms torsion-indicator that a very even turning moment, nearly without torsional vibrations, has been obtained through a particular arrangement and dimensioning of the transmission-shafts and a particular arrangement of the rotating masses arrived at by exact calculations and experiments.

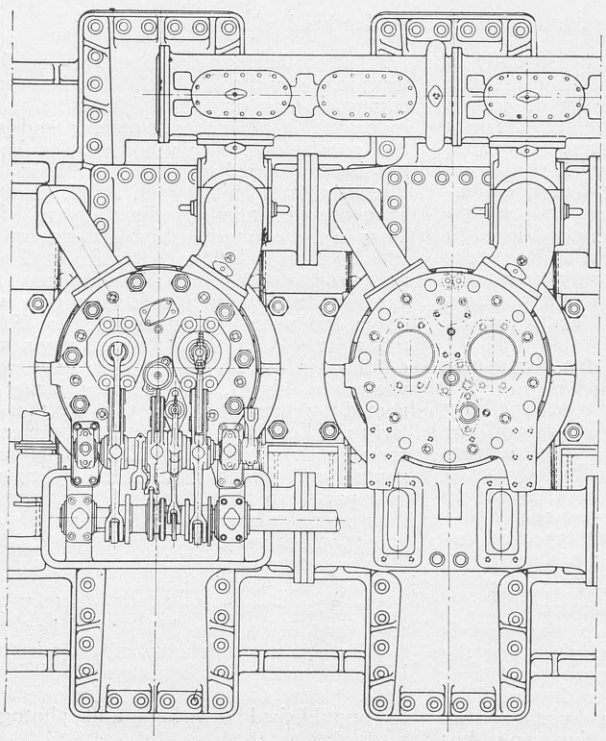

Fig. 7.—Cylinder heads of Blohm & Voss 1,750 b.h.p. marine engine

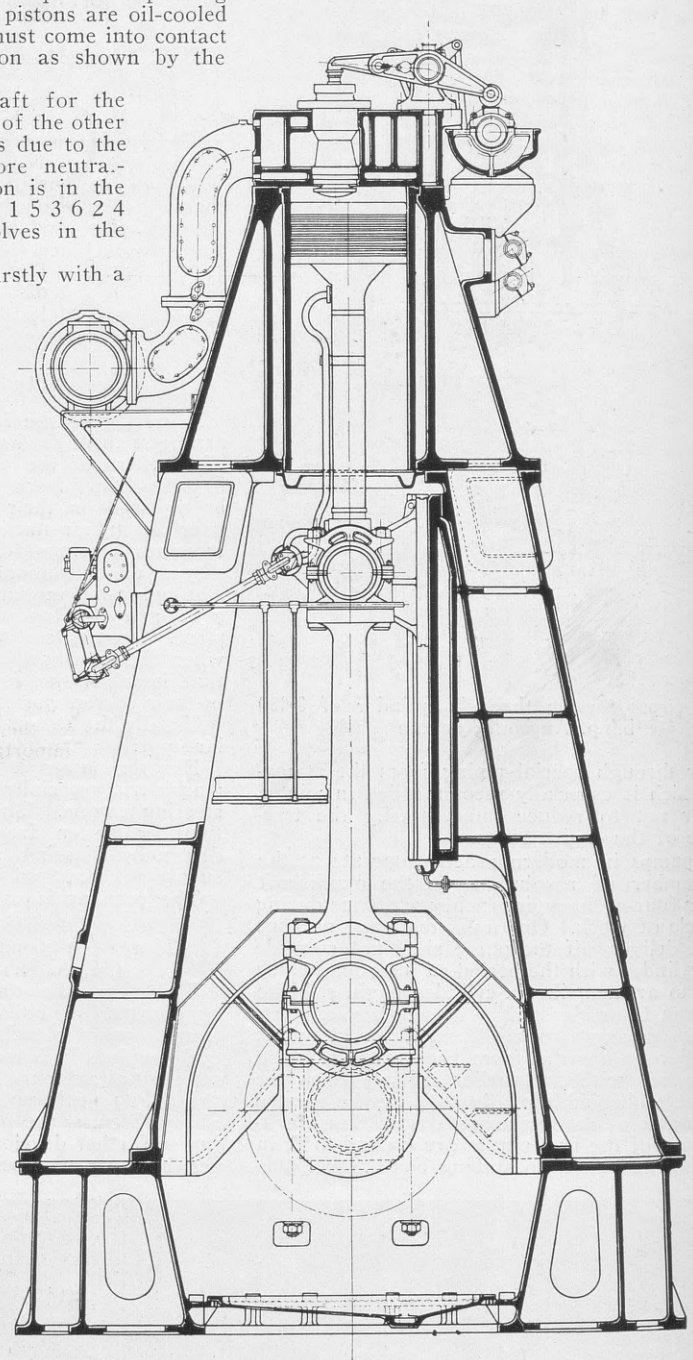

Fig. 9.—Cross section of Blohm & Voss 1,750 b.h.p. engine

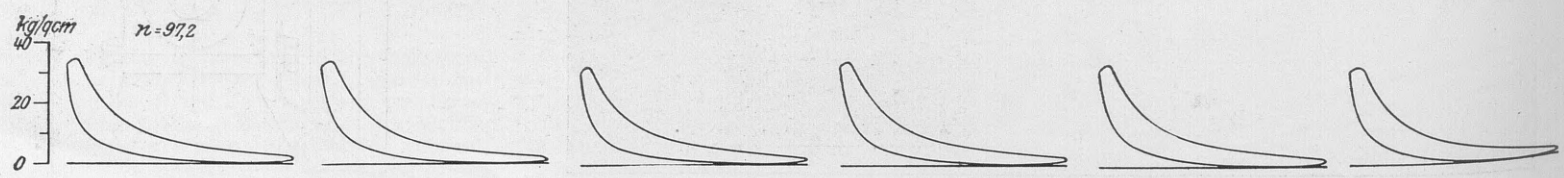

Fig. 8.—Diagrams from Blohm & Voss 1,750 b.h.p. Diesel engine

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Both ships have under actual working conditions shown great reliability, little wear and a favorable fuel consumption, so that the probability of using high-speed Diesel-engines in connection with reduction gear in the future is increasing. The firm Blohm & Voss has in the meantime obtained a new contract for a ship with 5400 h.p. with this system of drive.

Blohm & Voss have in addition hereto also built two engines of 1,750 b.h.p. for each of the ships RHEINLAND and ERMLAND; the ships themselves being built at the same yard for the Hamburg-Amerika Line.

A cross-section through the engine is shown in fig. 9. The Blohm & Voss engine is somewhat similar to the 1,600 b.h.p. engine of the M. A. N. because Blohm & Voss have an agreement with that firm. There are however some variations from the M. A. N. type including the somewhat bigger dimensions. The engine has for example

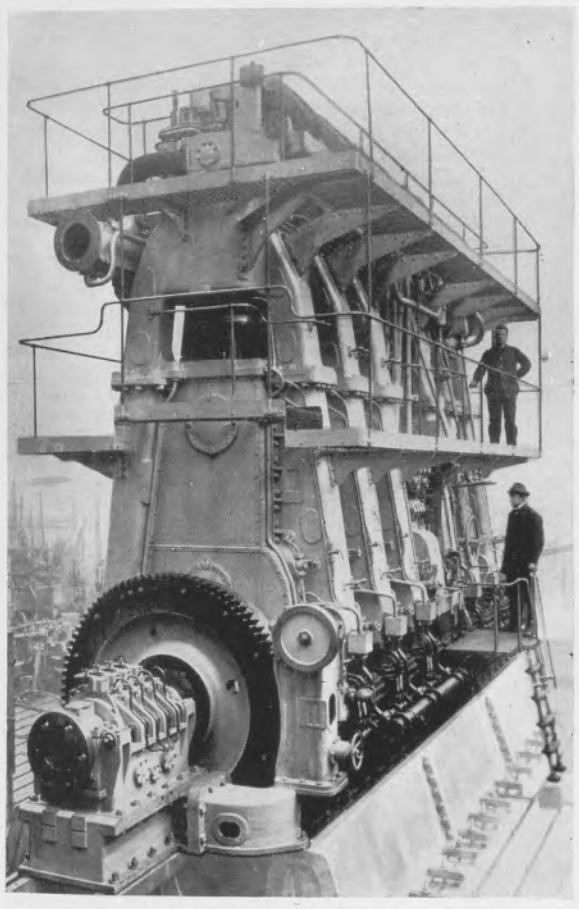
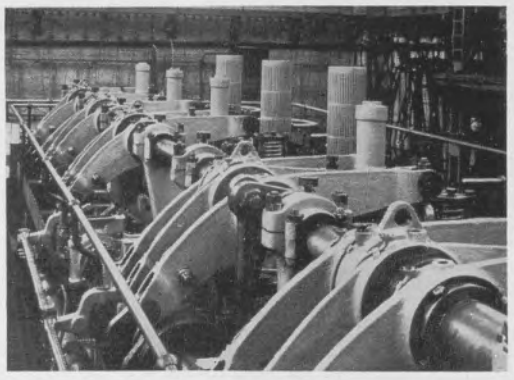


Fig. 10.—950 b.h.p. marine engine of Deutsche Werke

only one compressor driven from a crank at the end of the crank-shaft as compared with the M. A. N. design where there are two compressors driven by levers. The compressor of the Blohm & Voss engine is so dimensioned that it is sufficient for both engines when necessary. Each set of cams has a trough of cast iron for the lubricating oil, this trough being arranged in a simple and cheap manner on brackets cast into the cylinder casing on a level with the top of the cylinder. The important M. A. N. patent, namely the horizontal wall for a better circulation of the cooling water through the cylinder cover is also here made use of.

Two cylinder covers are shown in plan in fig. 7. Fuel, suction and exhaust valves are not arranged exactly in the center, this being in order to provide a better cross-section for the circulating water. The levers for these valves consist of two parts joined together by easily removable screws, so that the valve itself can be taken down when the short end of the lever has been removed. The connection between the stem and the water-cooled compartment of the exhaust valve is established by having the latter cast around the stem, a design which has proved very good.

There are many differences compared with the M. A. N. engine in the other details also—for instance, in the construction and cooling of the pistons, which here are cooled by sea-water and not by oil, in the valve gear, etc. The camshaft is, for example, driven through an auxiliary shaft with two cranks at 90° and connecting rods. The latter are divided in the middle by a double armed lever, as they would become otherwise rather long, the length for axial compression



F.g. 11.—Camshaft and valve levers of Deutsche Werke 950 b.h.p. engine

being thus reduced to half. The Brown reversing engine is here operated by compressed air as compared with the oil-pressure of the M. A. N.

Diagrams for a main engine are shown in Fig. 8. Each engine developed on the trial trip 2350 i.h.p. at 97.2 revolutions per min. average and had an average indicated pressure of 97.4 lbs. per square inch. The fuel consumption amounted to 0.292 lbs. per i.h.p. hr. The weight of the main engines without auxiliary machinery is 620 tons, that is about 390 lbs. per s.h.p. for a designed output of 1,750 s.h.p.

DEUTSCHE WERKE A.-G., WERFT KIEL

The Deutsche Werke in Kiel has built two engines of 950 b.h.p. (fig. 10) for a tank ship. The engines have now been severely tested in the shops. As they have already been described in MOTORSHIP, April, 1922, some hitherto unpublished illustrations are now given and some points discussed that have either not been described before at all or only quite briefly. These engines have some noteworthy peculiarities.

The frames fore and aft of the engine are placed unsymmetrically in regard to one another, so that connecting-rods, crossheads and main bearings are easy to inspect or to take down either from the front or back of the engine. Each cylinder stands with three especially long feet on the frames. The pistons also are for this reason easy to get at and easy to take down without the use of lifting gear exactly as in the Werkspoor engines. This design renders unnecessary the removal of the cylinder cover with the unavoidable emptying of the cooling water therein, and the stripping of piping, levers, etc. Particular importance is attached to the exactness of the valve gear and that the position of the gear is not influenced by the expansion of the frames due to the working pressure and the heat. Helical wheels are avoided; an auxiliary shaft as shown in fig. 12 is driven at half the revolutions of the crankshaft by means of spur wheels. The auxiliary shaft has two cranks at 90°. A second auxiliary shaft on a level with the cylinders and likewise with two cranks at 90° is driven synchronously from the first auxiliary shaft by means of connecting rods. The second auxiliary shaft is quite short and does not rest in stationary, but in movable, bearings supported by long rods from the bedplate as shown in fig. 13. The bearings are for this reason neither influenced by heating of the engine nor by the working pressure. The rotation of the second auxiliary shaft is trans-

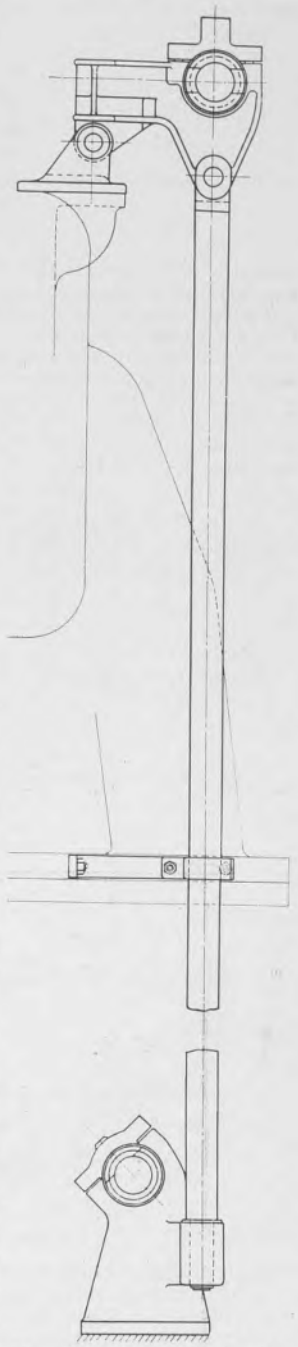


Fig. 13.—Camshaft bearing support on Deutsche Werke 950 b h p. engine

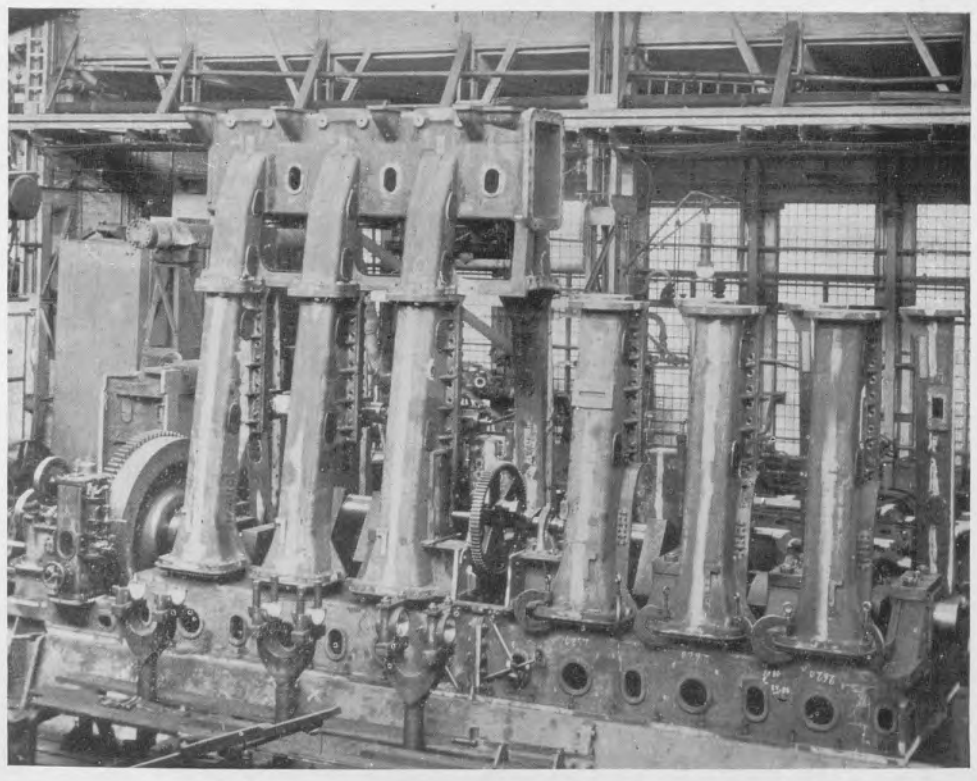


Fig. 12.—Framing of Deutsche Werke 950 b.h.p. engine

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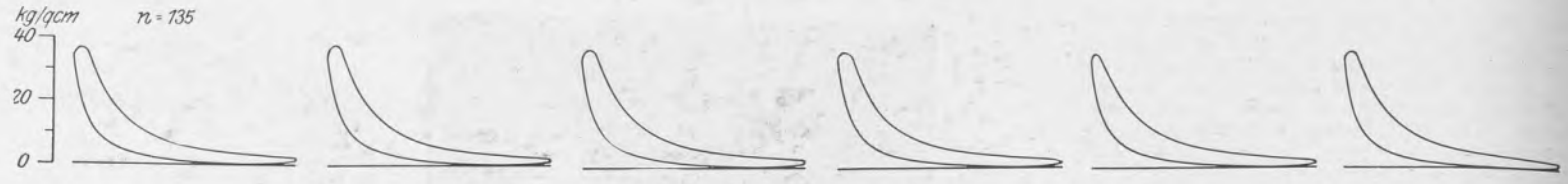

Fig. 14.—Diagrams taken from 950 b.h.p. engine of Deutsche Werke, Kiel

mitted to the camshaft through couplings that allow a small displacement.

The construction of the cylinders is shown in fig. 15. Three cylinders are made in one casting and these two blocks are then connected by a large flange, clearly shown in fig. 12. In this way a particularly rigid cylinder-block is obtained. The feet of the cylinders are connected below by a wall stiffened by ribs; this wall prevents the squirting of oil from the cranks on to the

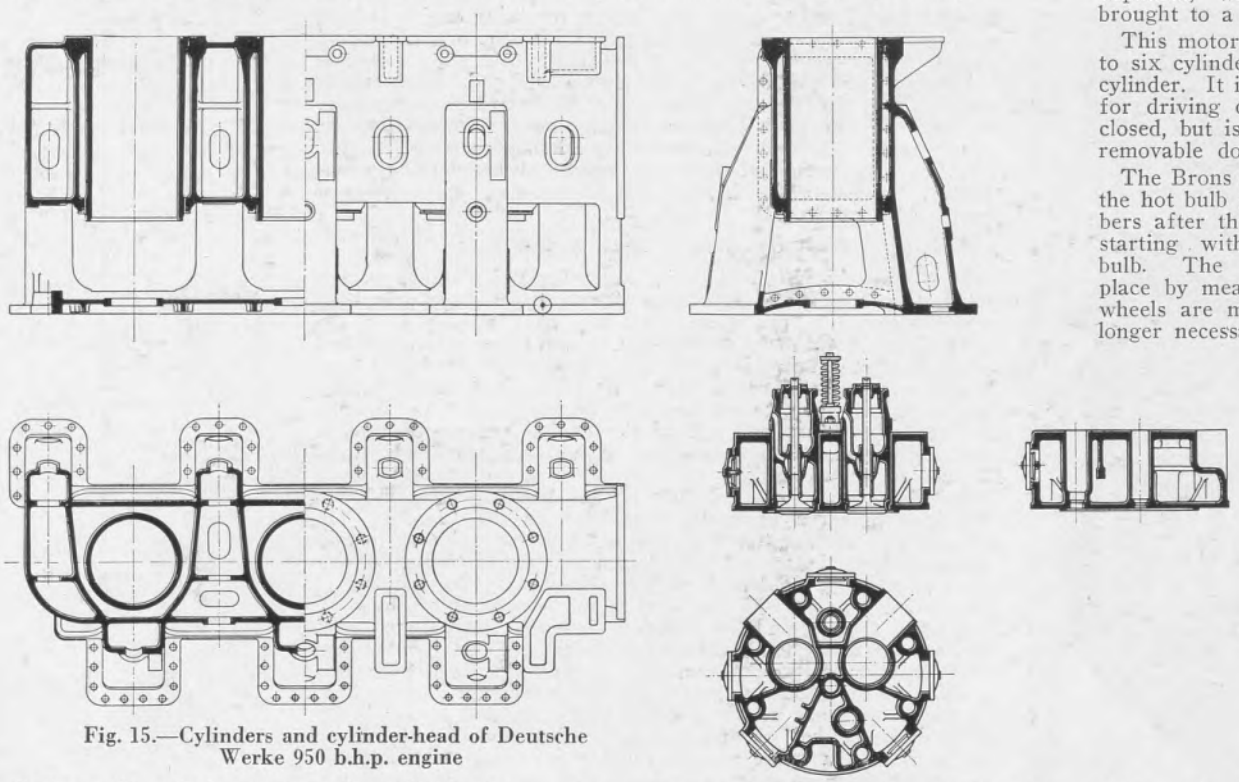

Fig. 15.—Cylinders and cylinder-head of Deutsche Werke 950 b.h.p. engine

cylinder walls, and also prevents the cooling water from dripping down into the crank chamber, and gives the cylinder casting extra strength. The rigidity of the six cylinders reaches a high degree because the two cylinder-castings also are connected to each other by flanges from this wall.

The fuel valve is not placed exactly in the centre, so that its casing may be well cooled by the cooling water as shown in fig. 15. The valve levers are shown in fig. 11 and diagrams taken at 1,000 s.h.p. in fig. 14. The fuel consumption amounted to 0.397 lbs. s.h.p. hr. at this output.

Starting air is heated by the exhaust gases, except when starting a cold engine, in order to save starting air and also to cool the cylinders themselves as little as possible when starting. Both the three-stage compressors are driven by levers and are placed low down in the neighborhood of the floor.

There are, besides these engines, two other engines of the same size and design building, and also a third similar engine of 1,750 s.h.p.

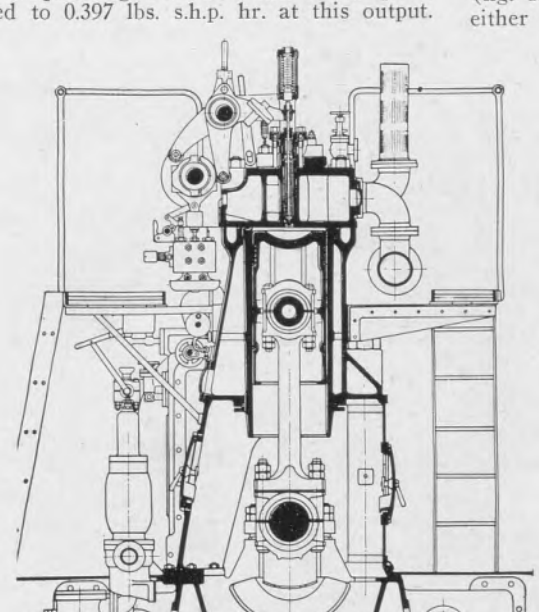

Fig. 16.—Section through 180 b.h.p. auxiliary engine of Deutsche Werke

A cross-section is shown in fig. 16 through a three-cylinder Diesel-engine of 180 b.h.p. without cross-head for driving auxiliary machinery. The cylinders are carried by frames on one side and steel columns on the other side in order to obtain facilities for inspecting the engine and also for taking down the different parts. The columns are easy to remove, which is especially useful when the crankshaft has to be taken out, (fig. 17). All driving parts are easy to get at either from fore or aft. The valve operation takes place by means of an auxiliary shaft and two connecting-rods, as in the bigger engine.

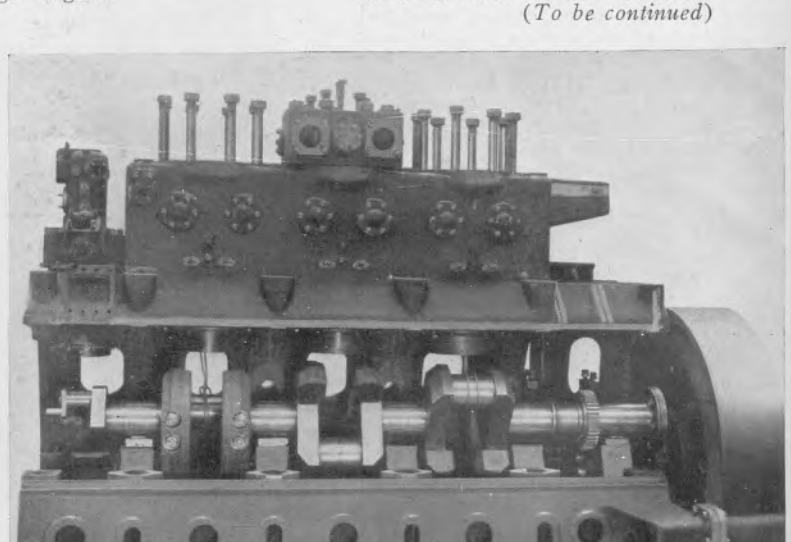

Fig. 17.—Removing crankshaft of Deutsche Werke auxiliary engine

MOTORENFABRIK DEUTZ IN KÖLN-DEUTZ

This firm has lately produced a still simpler design of the Brons marine oil engine than the earlier type. The new type is of bigger output than has hitherto been built, and the fuel consumption has also been reduced. The Brons motor operates, as is well known, after a somewhat simpler four-cycle system than the Diesel-engine. A small portion of the fuel is first exploded, whereupon the remaining part is brought to a slower combustion.

This motor is now being built with from two to six cylinders with outputs up to 20 s.h.p. per cylinder. It is much in use for fishing boats and for driving dynamos. The motor is quite enclosed, but is easily accessible by means of big removable doors.

The Brons engine has the great advantage over the hot bulb motors which so increased in numbers after the war, that it is always ready for starting without preliminary heating of the bulb. The driving of the camshaft takes place by means of spur wheels, so that helical wheels are made unnecessary. Kerosene is no longer necessary for starting as the motor now starts directly on the better grades of gas-oil. The fuel consumption has been reduced to 0.455 lbs. per s.h.p. hr. for some motors. The small compressor which is necessary only for starting purposes, delivers air with a maximum pressure of about 230 lbs. per sq. inch. For starting about 100 lbs. per sq. inch are generally sufficient. The compressor is uncoupled when the starting air bottle have been pumped full.

In its latest design, the fuel atomizing chamber, which is made of Siemens-Martin steel, projects somewhat into the lower part of the clearance space of the cylinder and it is thus always kept warm. The many holes in the bottom of the chamber are only drilled in the side opposite to the centre of the cylinder and narrowed somewhat on the outside by means of a special tool. The fuel injection valve is opened just before the dead centre by means of a lever which in turn is operated from the lever of the suction valve. Then the oil which has been pumped into the pipe "z" during the suction stroke, flows into the fuel chamber. The fuel pump does not have any resistance worth mentioning when delivering as in the case of the Diesel-engine. The oil can be brought directly to the valve head by means of this pipe "z," as the channel "k" is made somewhat bigger, in order to make it easier to drill.

(To be continued)

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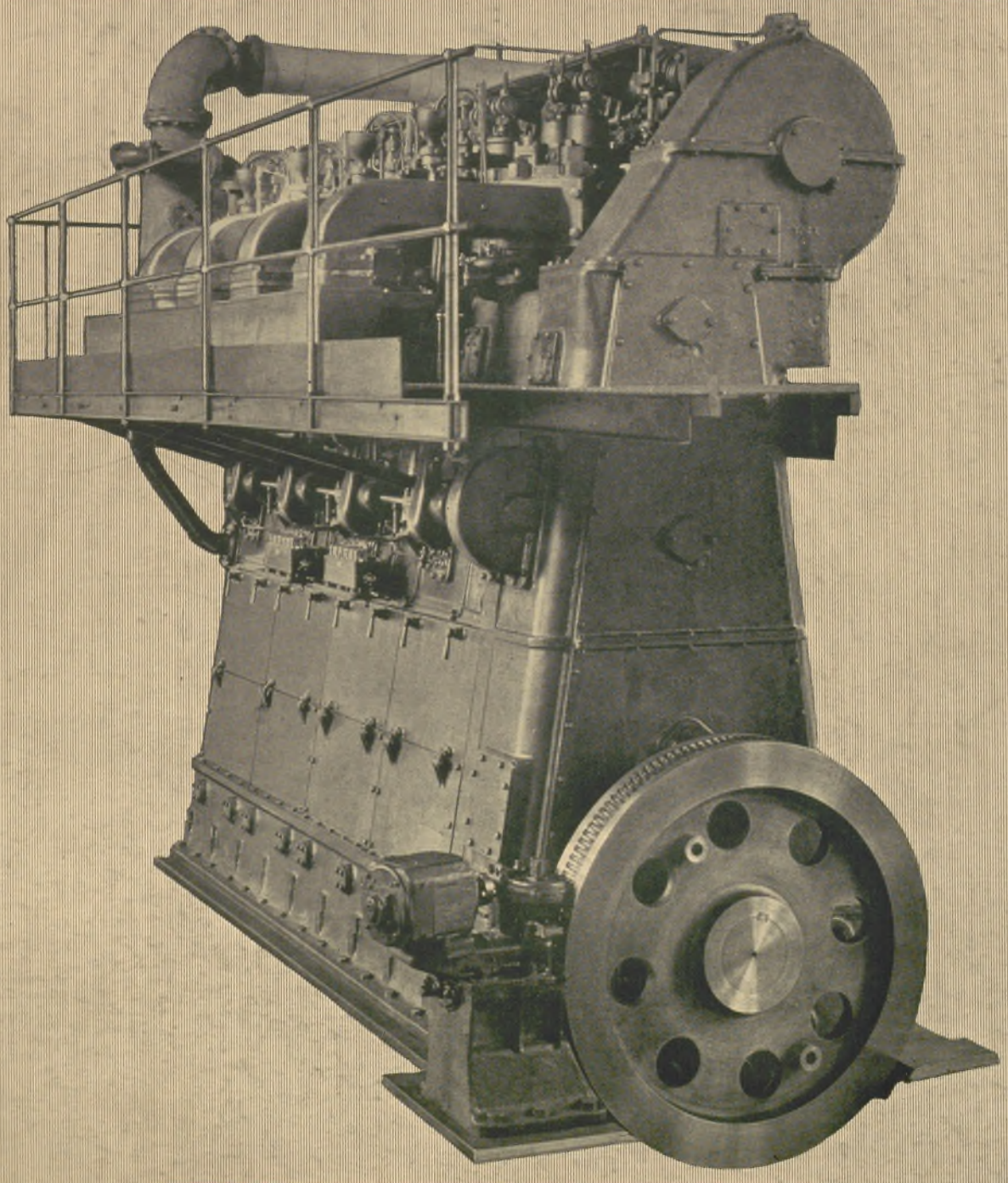
MOTORSHIP

SPECIAL FALK SUPPLEMENT

Advertisement Supplement to the May 1923 Issue—Not Mailable as Second Class Matter



INTRODUCING THE FALK OIL ENGINE

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Falk Corporation
MILWAUKEE, WIS.
U. S. A.

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Otto H. Falk - - -	*Vice-President*
Emanuel A. Wurster -	*Secy. & Treas.*
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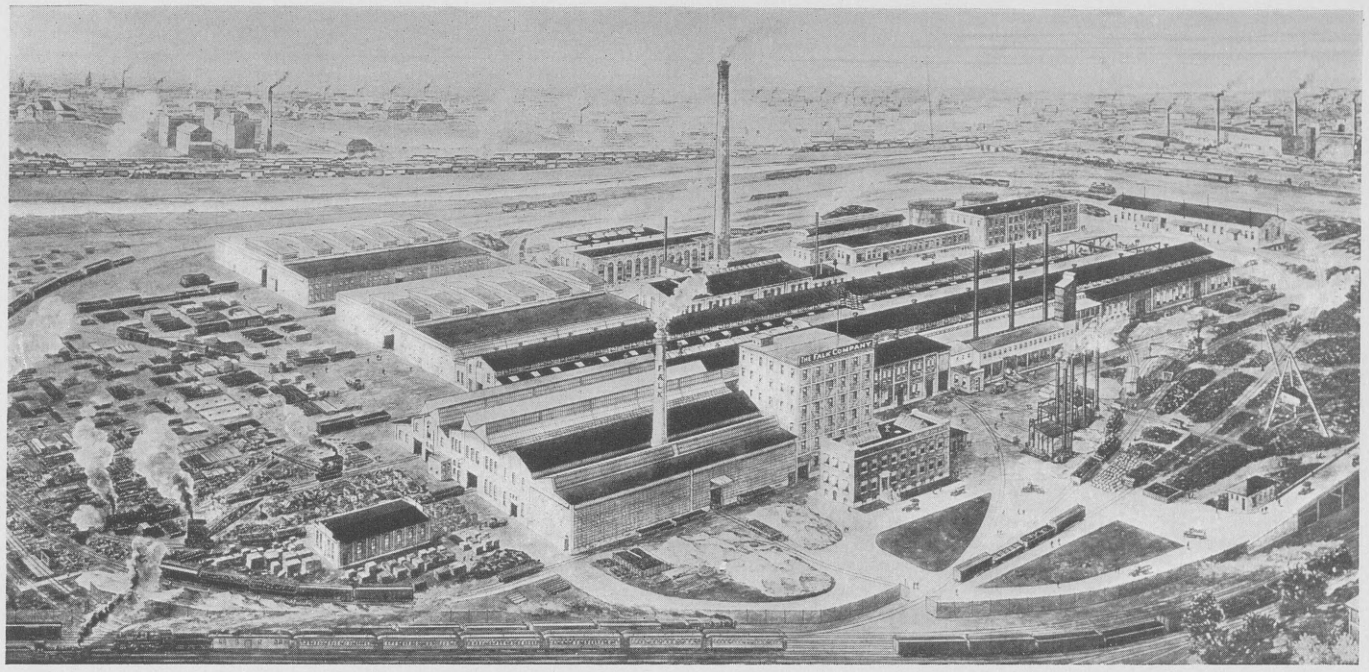
INTRODUCTORY



General View of the Falk Plant at Milwaukee, Wis.

THIS Supplement, which will also afford a comprehensive conception of The Falk Corporation's manufacturing facilities, will directly bring to the attention of shipowners, shipbuilders, and naval-architects a remarkable merchant-marine propelling-unit of an entirely new type. This mechanism represents a distinct engineering achievement often considered and projected by numerous designers, but not previously put into actual being except in small powers because of the enormous expense involved in the production of a practical and reliable job. In just the same way many American engineers have long looked towards commercial attainment of the big double-acting oil-engine, but have realized that the task involves tremendous difficulties combined with large financial expenditures.

Neither expense nor talent has been spared to make the Falk oil-engine the last word in propelling mechanisms of today and its construction has been watched with great interest from the start to the finish by the Editor of MOTORSHIP through the courtesy of The Falk Corporation. It has required two years concentration of a considerable proportion of the constructional facilities of the Corporation's great plant and its engineering staff, aside from the actual expenditure of over half-a-million dollars, to make this new unit the engineering success that it is today. It is believed that never before was such a complete engine-room equipment constructed, erected and made available for immediate installation in advance of purchase by a shipowner.

In constructing the four 550 shaft horsepower direct-reversible marine-engines that form the unit now running regularly in the Corporation's powerhouse at Milwaukee, the new oil-engine department had the great advantage that it had not to

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worry about the reduction-gear, the Works already being equipped with unusually fine machine-tools especially adapted for this highly specialized and exacting work, as well as with one of the best steel foundries in the country that fortunately forms part of the Plant. The same high standards as applied to the Falk Corporation's gear work were dominant in the building of these oil-engines. Consequently better workmanship never entered into the manufacture of a Diesel engine. This feature of good construction is highly important from the aspect of absolute reliable operation under the most arduous of sea-going conditions, as even with sound design a poorly built engine will prove unreliable in service.

There are four reversing engines driving a single propeller-shaft through reduction gears—a task hitherto unattempted in the annals of marine Diesel engineering, so the effort and skill embodied in the production of the unit was enormous. The result is a very fine power-plant particularly suitable for installation in existing hulls or in new ships, as the present shafting—generally too small for direct Diesel drive, can be retained. All the engine-room auxiliary machinery necessary for the unit's operation has been erected in the power-house, the unit being entirely self-contained and ready for transfer to the engine-room of a ship.

Each engine is reversible in itself but will be built non-reversible for marine electric drive, or for stationary power-plants. Also twin engines with or without gears of similar or higher power will be constructed for suitable installations, plans having been made for the manufacture of such sets.

In conformance with the policy maintained since the Falk plant was established in 1894, the Directors and their engineering-staff had to satisfy themselves absolutely that the finished product was practically flawless in every way before marketing the engine or permitting details to be published. Exhaustive and severest possible tests have been satisfactorily completed on these engines. Shipowners, shipbuilders and consulting engineers are now invited to go to the Falk plant at Milwaukee, and inspect the complete unit, witness its operation under full, partial and over-loads, and become satisfied that it is an All-American Diesel-engine plant possessing special advantages and merits for ship propulsion.

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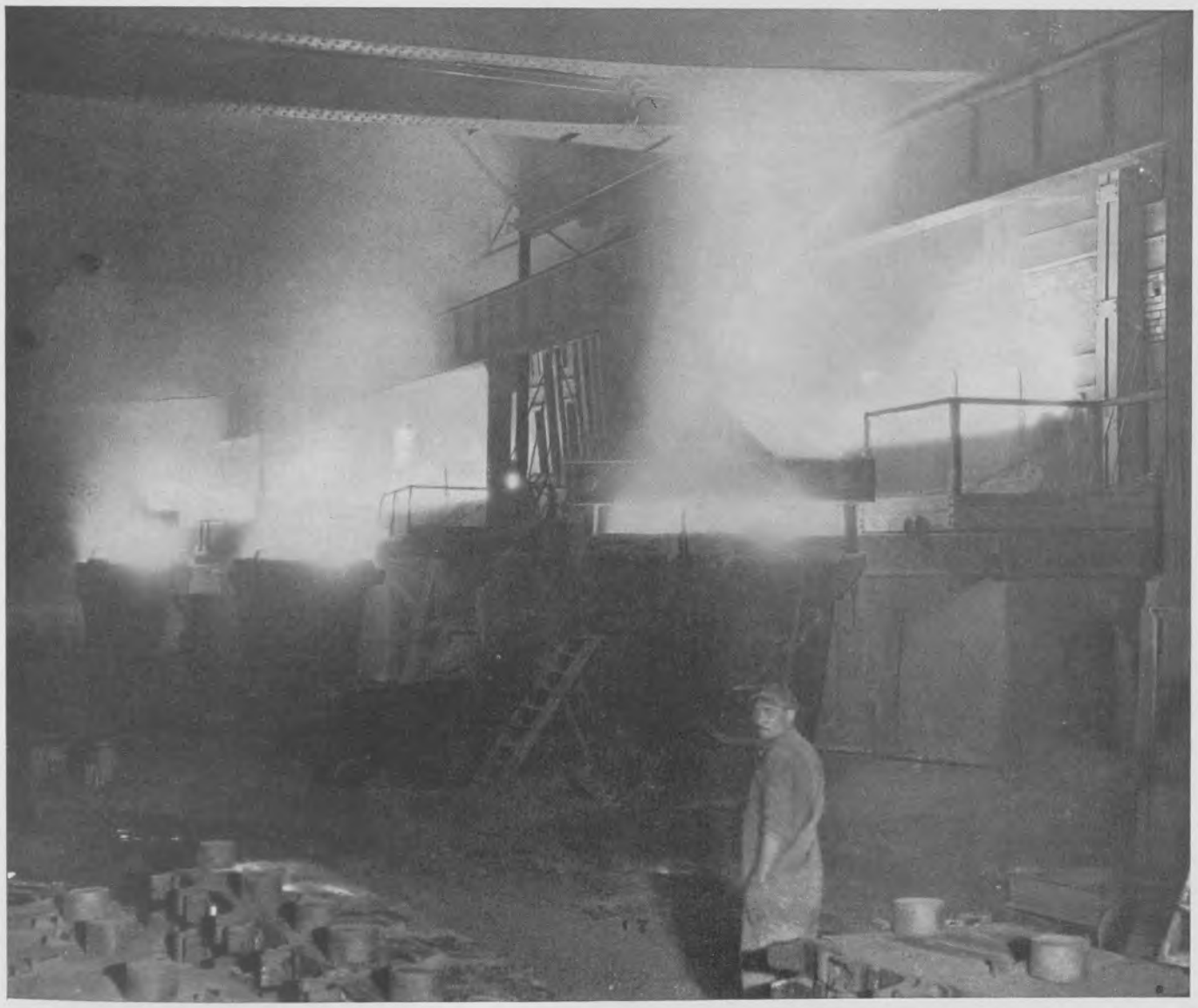
The Plant of the Falk Corporation

Some Information Concerning the Modern Shops Where The Falk Oil-Engine Has Been Developed

SERVED by two important railroads, one of which has a clear run to the Pacific, and situated on the shore of one of the chain of vast fresh-water lakes that are linked by canal to New York and connected to the Atlantic Ocean by the mighty St. Lawrence River, the City of Milwaukee in the State of Wisconsin is naturally suited for the great industrial center which it has become. Its propinquity to Chicago (the world's third largest city) and to St. Louis, which are two great oil pipe-line terminals, make this place ideal in many ways for both marine and stationary oil-engine construction on an economical basis. The great distance from the sea has but little drawback under the circumstances, it being more than offset by the close proximity to the big ore ranges allowing certain raw material advantages.

It is in this city that the works of The Falk Corporation were founded in 1894 and have since expanded to their present capacity. The problems of coal and miners' strikes is no vital factor in this establishment because oil is used exclusively in the large foundry. The plant is situated in the Menominee Valley in



The Steel Foundry: three open-hearth furnaces simultaneously tapping 188,000 pounds of steel for the gear blank shown on the hobber on page sixteen

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The Steel Foundry; moulding bay for medium and heavy work

The Steel Foundry; core-room for medium and heavy work

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The Steel Foundry; Chipping Department for Heavy Castings

The Steel Foundry; mould drying ovens for medium and heavy work

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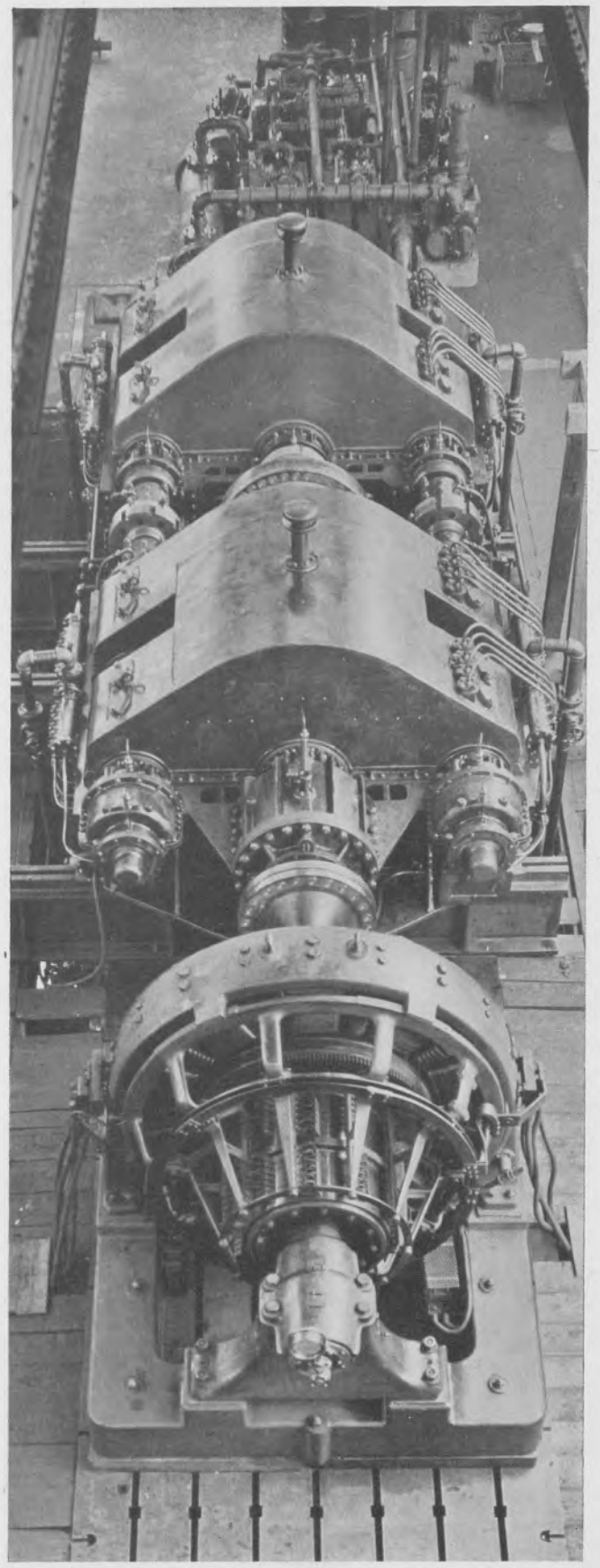
the West section of Milwaukee, alongside the freight yards of the Chicago, Milwaukee and St. Paul railroad, and so is very accessible for delivery and shipment of raw materials and products. It occupies an area of 50½ acres, a goodly portion of which is covered by buildings, 10½ acres to be exact, leaving plenty of ground available on the property for further extensions in the way of new shops.



Torsion-shaft method of loading and testing two large marine-gear units. Each of the above units transmits 24,000 h. p. between the turbine and ship's propeller-shaft

On the north side of the plant is the main office, a modern three-story brick building, 106 ft. by 42 ft., containing the executive, clerical and drawing offices, as well as the restaurants for the officials and general staff.

Immediately south of the main office is the steel foundry, 925 ft. long by 265 ft. wide, which is one of the finest in the country. In this building are produced acid open-hearth steel castings to the normal output of 25,000 tons per year from its three 30-ton furnaces. As the latter are entirely oil-fired for melting and consume three million gallons of fuel annually, the nearness of Milwaukee to the pipe-line terminals and refineries means another economical benefit towards reducing manufacturing costs. This quantity of fuel would drive a 10,000 ton 12-knot motorship more than 120,000 miles or more than four times around the world. An illustration on page nine shows the three furnaces tapping simultaneously.

There are three large machine and erecting shops, one being 625 ft. in length with 100 ft. breadth, on the south side of the foundry, and their output is confined exclusively to the production of Falk gears, Falk oil-engines and Falk - Bibby flexible couplings. The two smaller machine shops are both 275 ft. long by 175 ft. wide. Shop No. 3 was the last extension of the machine department, and can be seen on the extreme left of the illustration on the introductory page. Shop No. 2 was completed in 1917 and is in three bays. The equipment of these three machine shops is thoroughly modern and includes only the most powerful and up-to-date tools of their particular type. Many of the illustrations in this Supplement will give a comprehensive idea of the fine machine tools, such as heavy boring mills, planers and gear-hobbers, the planers being equipped with reversing motor drive.

There are twelve gear-hobbing machines among which are the largest and most powerful

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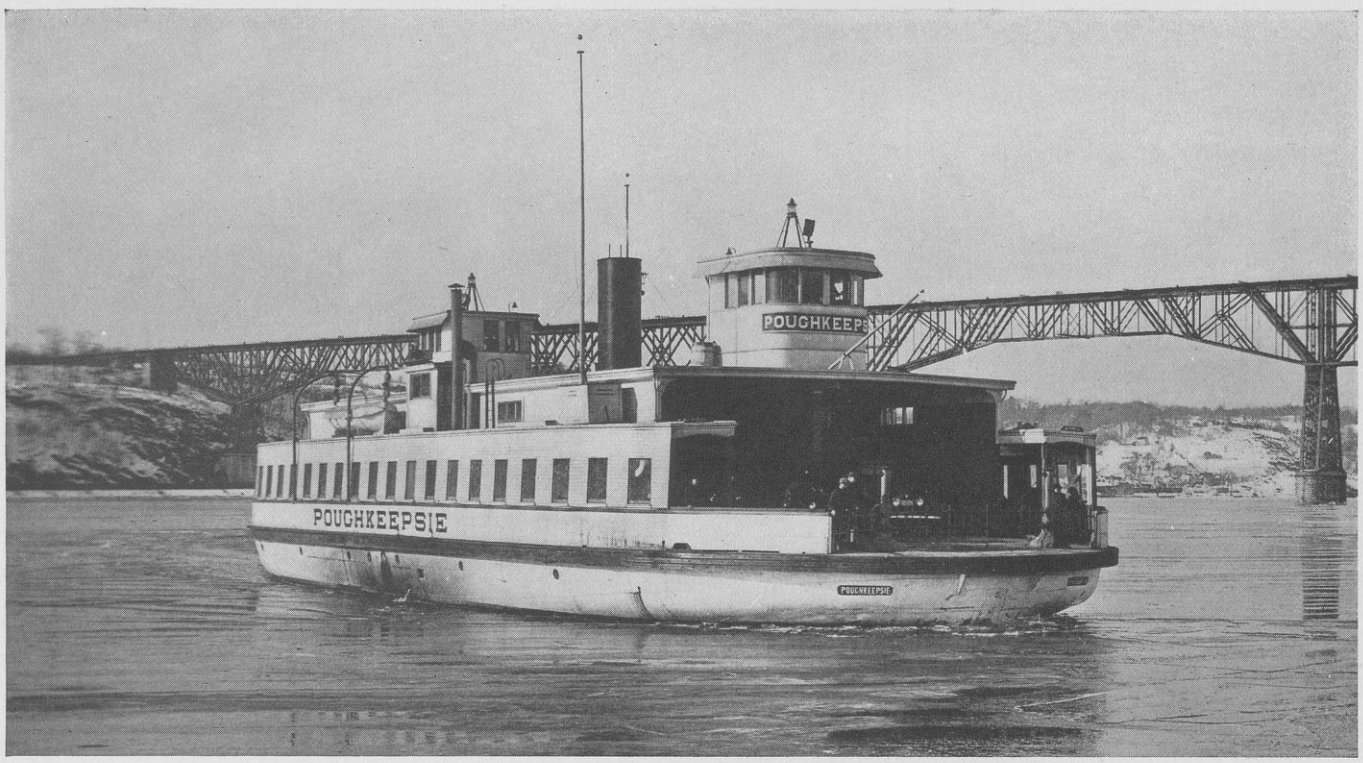

Winton-Westinghouse Diesel-electric Ferry-vessel "Poughkeepsie" on the Hudson. The introduction of Falk reduction-gears and Falk-Bibby couplings considerably increased her speed

in existence; it is worthy of special record that all were designed by The Falk Corporation for their own use and were constructed in their own shops. Other interesting equipment includes a complete plant for the manufacture and subsequent upkeep of the hobs used in the gear-cutting machines, as well as a number of special tools for boring each gear-housing and groups of oil-engine cylinders. These also were all designed and built by The Falk Corporation.

With the exception of a few light machines in the tool-making department, every tool is provided with individual motor drive, some of the largest tools and gear-hobbing machines being equipped with three and four motors each, with a complete system of push-button control.

In addition to the foregoing departments there is a pattern shop 300 ft. by 60 ft., a blacksmith's shop, a brass foundry and a number of other minor buildings. Then there is the power-house 200 ft. by 90 ft., which has a capacity of 3,500 kilowatts of electrical power in addition to a complete compressed-air system. Continuous current is furnished at 240 volts. The 2,200 shaft h.p. Diesel engine unit has been erected in a part of this power house, and the current produced by it is used for operating the machinery of the works.

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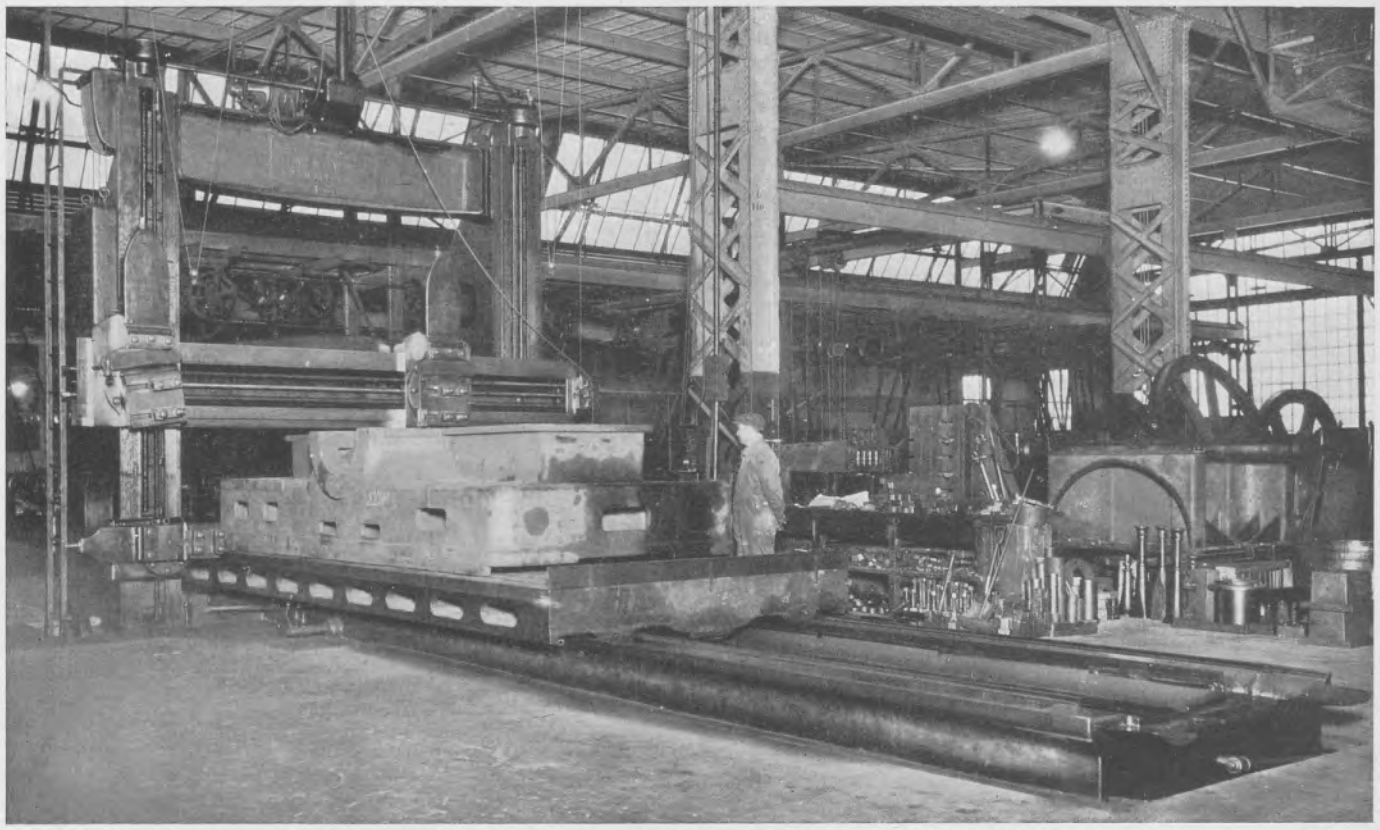

A big planer machining a heavy casting

Rough casting of gear blank referred to on pages nine and sixteen

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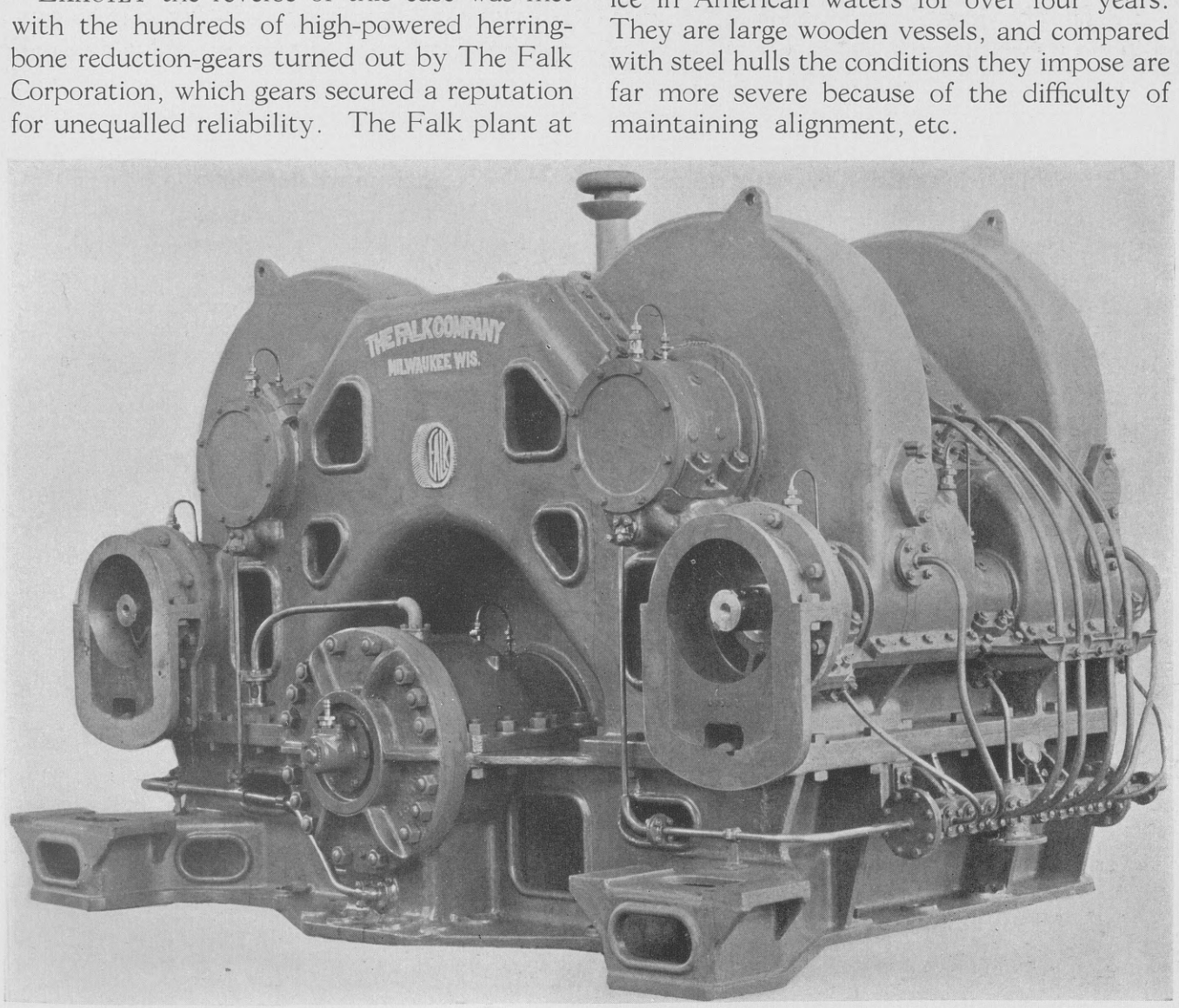
Falk Marine Reduction Gears

The Design and Construction of Herringbone-Type Units for Diesel-Engines and Steam Turbines

IT was during the war and the two years following that turbine reduction-geared power-plants came into such prominence for merchant ship and destroyer propulsion. The sudden enormous demand and the rapidity in which they were required combined with the difficulty of securing the highest grades of materials and labor, as well as their construction being undertaken as a side line by firms inexperienced in the task, were causes for a certain amount of trouble being experienced in operation with some of the wartime built units.

EXACTLY the reverse of this case was met with the hundreds of high-powered herringbone reduction-gears turned out by The Falk Corporation, which gears secured a reputation for unequalled reliability. The Falk plant at Milwaukee was specially designed, erected and laid out for the manufacture of gears exclusively. For twelve years the firm has been continually developing this product and long before the War was over attained its present high stage of perfection. Of course, during the War the plant was considerably enlarged, but not to an unwieldy stage. Consequently, all the Falk geared units installed in merchant and naval vessels have been eminently successful in the hard service to which they have been subjected, often in unskilled hands. Two Diesel-engined motorships with Falk reduction-gears have been in most satisfactory service in American waters for over four years. They are large wooden vessels, and compared with steel hulls the conditions they impose are far more severe because of the difficulty of maintaining alignment, etc.



A typical Falk merchant-marine 3,000 s. h. p. turbine double reduction-gear unit ready for installation in a ship

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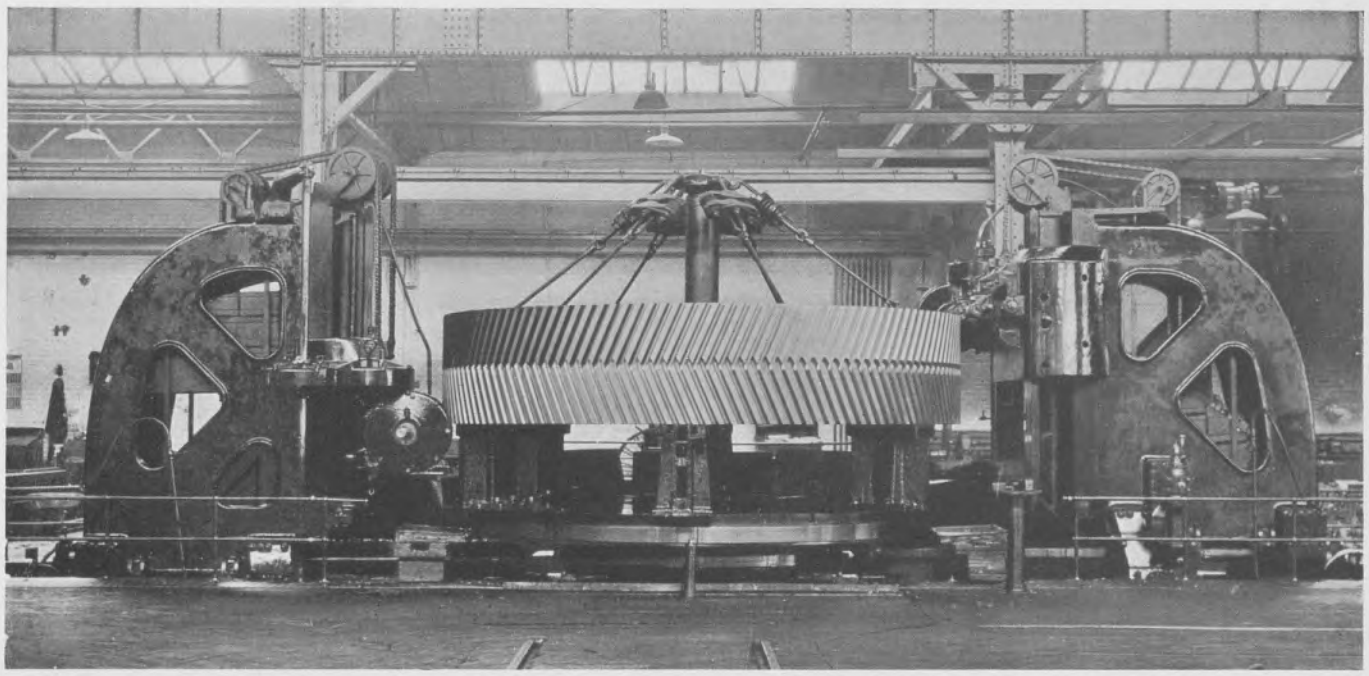

Cutting the teeth of the gear referred to on pages nine and sixteen, 16 ft. dia., 40" face, finished weight 75,000 pounds

By far the greater proportion of marine reduction gears manufactured up to date have been used in connection with steam turbines. With gears of this class transmitting in many cases several thousands of horsepower from a single-pinion an unusually high standard of workmanship is necessary in order that they may operate smoothly and without vibration in ships at very high speeds.

The first gear drives used for marine propulsion were more or less successful, because the power transmitted was relatively small and the speed of the turbines was kept as low as possible in order to favor the gears. But a more extended application of the geared turbine led to the transmission of higher powers at greater speeds. Difficulties developed which could only be overcome by improving

View of machine shop for cutting commercial gears with gear blanks and pinions in the foreground

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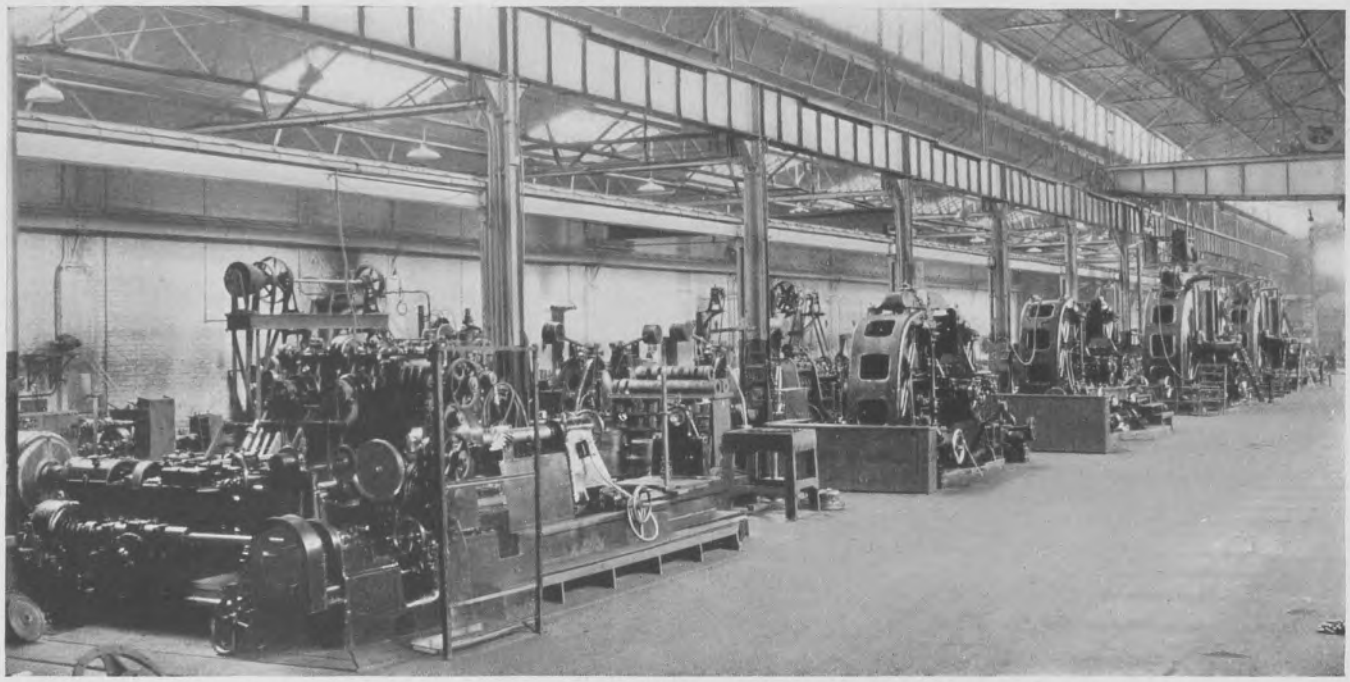
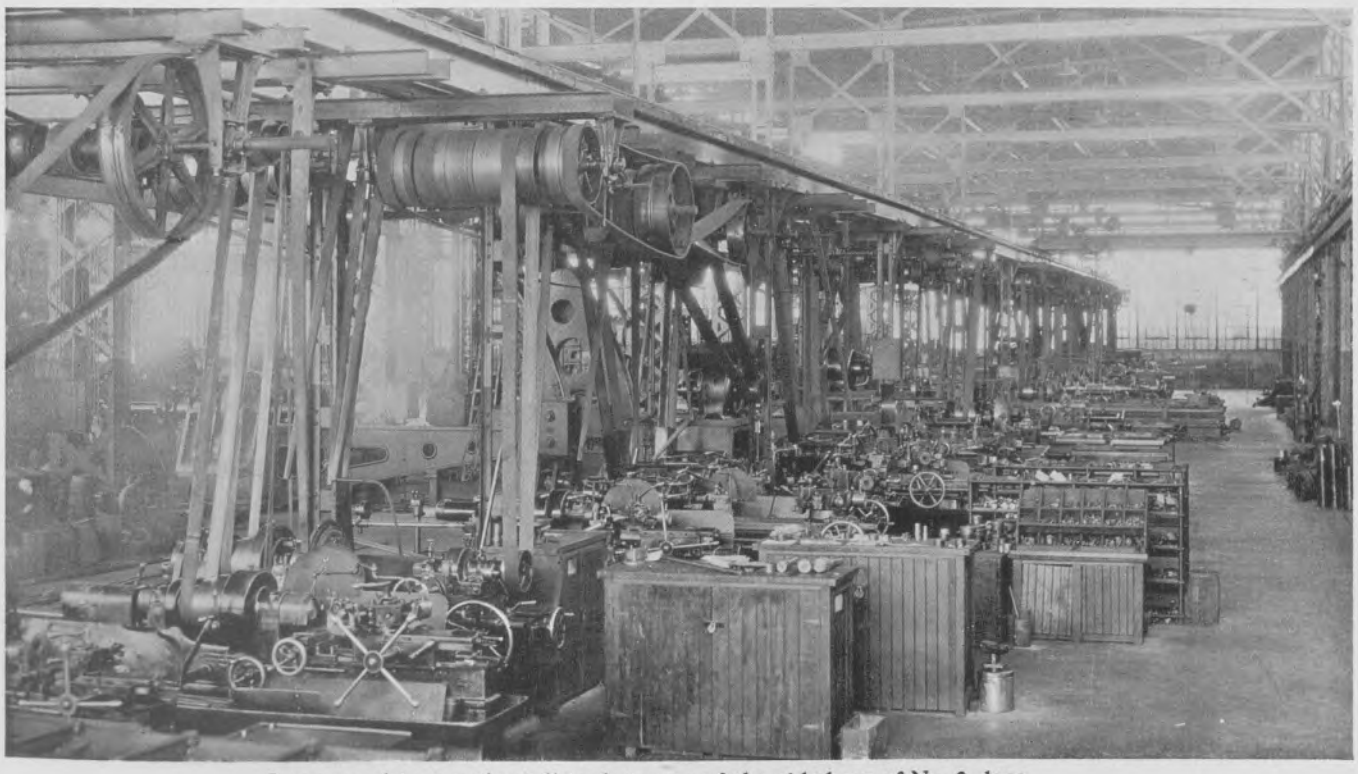


Battery of gear-hobbers in No. 1 shop. The tool in the foreground was especially built for high-speed turbine gears, all machines built by the Falk Corporation

the standards of accuracy in gear cutting and in the general manufacture of gear units until they met the exacting requirements of modern marine propulsion in a perfectly satisfactory and reliable manner.

A MODERN plant for the production of gears of this class must be equipped with special machinery for performing many different operations incidental to the production of a high grade marine gear unit. In order to meet these conditions the Falk Corporation, instead of purchasing all the machine tools in the general market, designed and built for its own use a number of gear-hobbing machines of special design and construction which are believed to be the most powerful and accurate tools of their kind in existence. Some of these gear-hobbers are shown in the accompanying illustrations and include vertical machines for the larger gears, and horizontal machines for



Screw machines and small tools in one of the side bays of No. 2 shop

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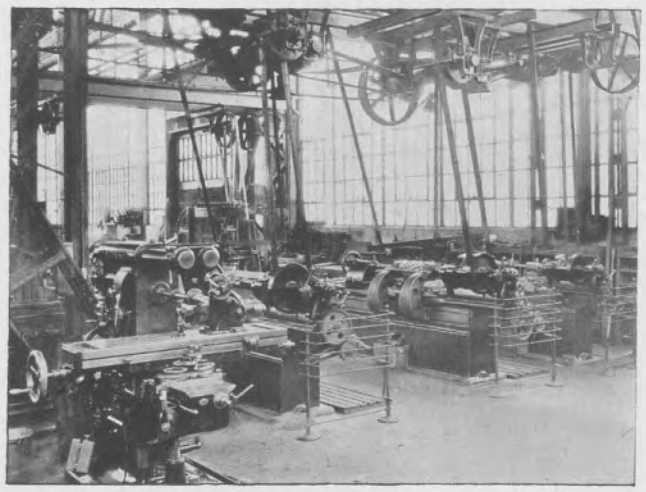
pinions and gears of smaller diameter. Other machine tools for ordinary work are of well-known makes.



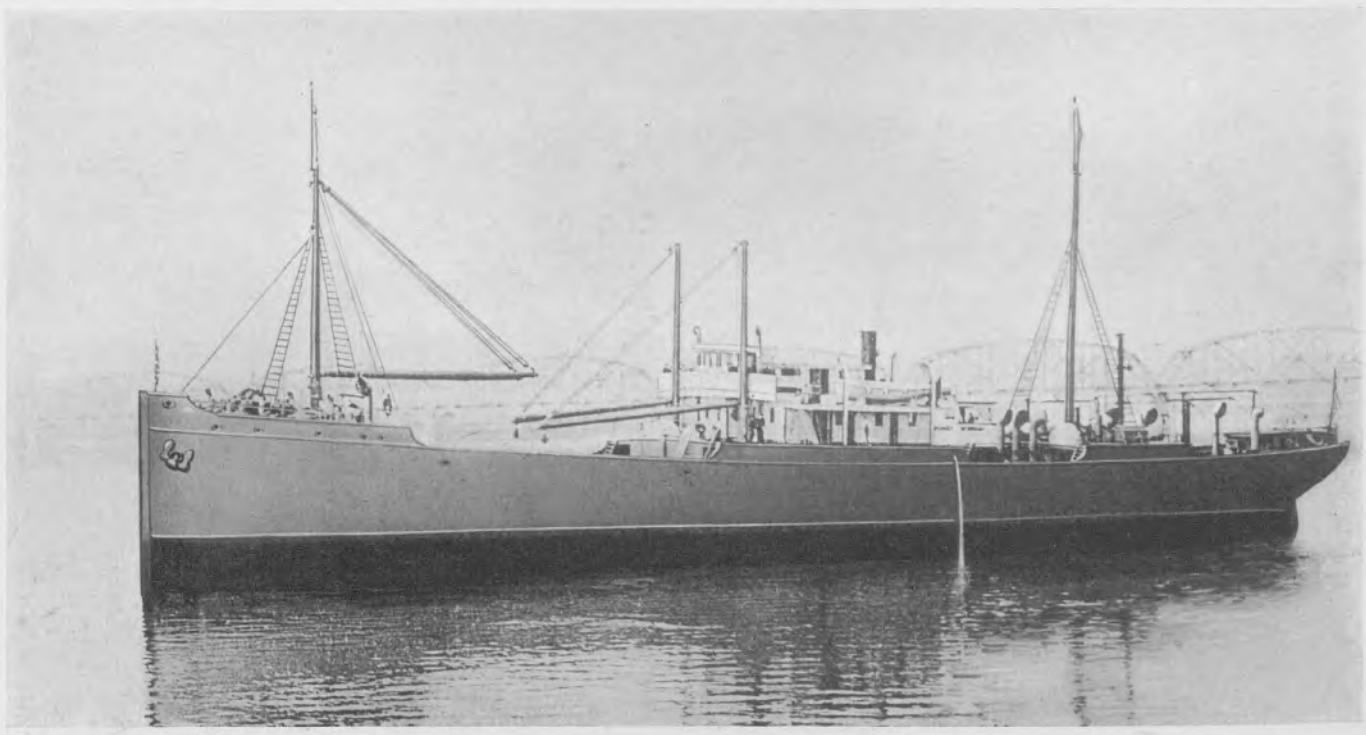
Relieving-lathes used in the manufacture of hobs. The two larger ones were designed and built by The Falk Corporation

WHEN it is desired to produce a very accurate gear, a precision hobbing-machine alone is not sufficient for the purpose. Provision must be made to insure that the accurately divided pitch-circle of the gear will be truly concentric to the axis of the shaft on which it has to be mounted. For this reason Falk marine gears are always mounted on finished shafts before they are trued in a special lathe as a final preparation for gear cutting.

ACCURATE gear cutting itself is not permanent unless the gear is so constructed that it will not distort sensibly from its original form when subjected to varying stresses and temperature changes in service. Particularly with marine installations is this highly important as the machinery is subject to stresses due to movements of the hull of the ship under the different strains of light and loaded conditions and varying seas.

THE Falk Corporation's marine gears are almost invariably made from open-hearth steel castings produced in their own foundry. Great care is exercised in the design and construction of these gears to insure freedom from shrinkage stresses in the castings. When a casting is first taken out of the sand it is thoroughly annealed and then sent over to the machine shop to be rough turned all over. Then the casting is sent back to the annealer a second time before the machine work is completed. After leaving the gear-cutting machine the gears are subjected to the final processes of polishing and balancing before they are assembled in the gear case.

HOWEVER, the problem of a successful gear-unit does not rest entirely with the afore-mentioned parts, because the precision work on the gears themselves is of little value unless



American motorship "James Timpson," propelled by two 500 shaft H. P. Winton Diesel engines thru Falk reduction-gears. Owned by I. T. Williams & Co., New York

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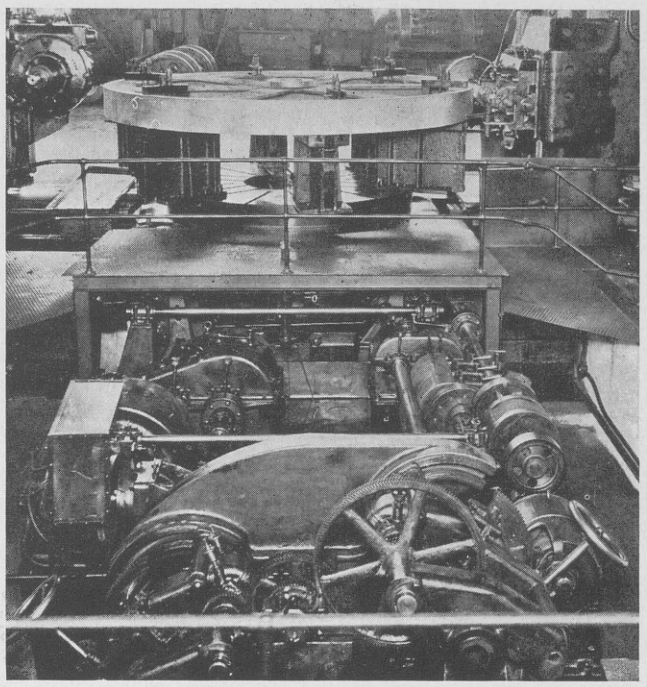
the gear frames, or housings, are finished with corresponding precision. The shafts of both gear and pinion must lie exactly parallel in the bearings in order to insure the full contact over the width of the gear faces and an even distribution of load across the teeth. In order to meet these conditions the Falk Corporation has also constructed special boring machines for performing this exacting part of the work.



The electric driving mechanism of the big gear-hobber illustrated below

THE assembled gear unit is always tested at full speed before shipment. Sometimes it is desirable to test these gear-units at full load and speed. One illustration in this Supplement shows the apparatus by which these tests can be carried out without requiring more than a small fraction of the power for which the gears are rated. Two gears are required for such a test and they must be identical in dimensions. The gear units are connected together through all shafts and are loaded by twisting special torsion shafts interposed between the two units. A large motor is connected from the outside to one of the shafts and furnishes power to overcome the internal friction of the two units. The load actually circulates between one unit and the other, whilst the motor supplies the losses.

THIS is the mechanical equivalent of the method which has been used for many years for testing electric motors and generators. Since the efficiency of a gear unit of this class generally lies between 97% and 99% it follows that the power required for a full load endurance run by this method only amounts to a very small fraction of the total horsepower circulated.

WHILE there is no difference in the standard of workmanship between a marine turbine gear-unit and a similar unit for a geared oil-

One of the four largest gear-hobbers ever built. The other three are also in the Falk shops. It can hob the toughest cast-steel gears up to 16½ ft. diameter. All were built by The Falk Corporation

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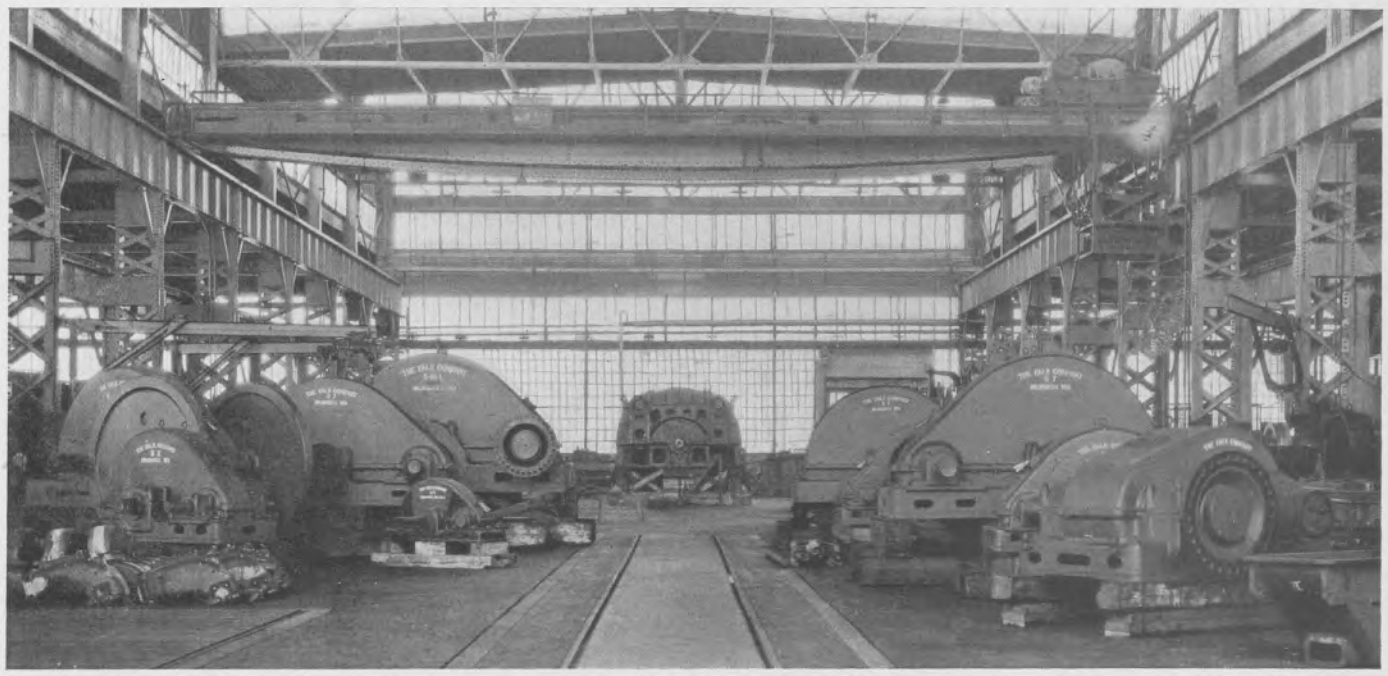
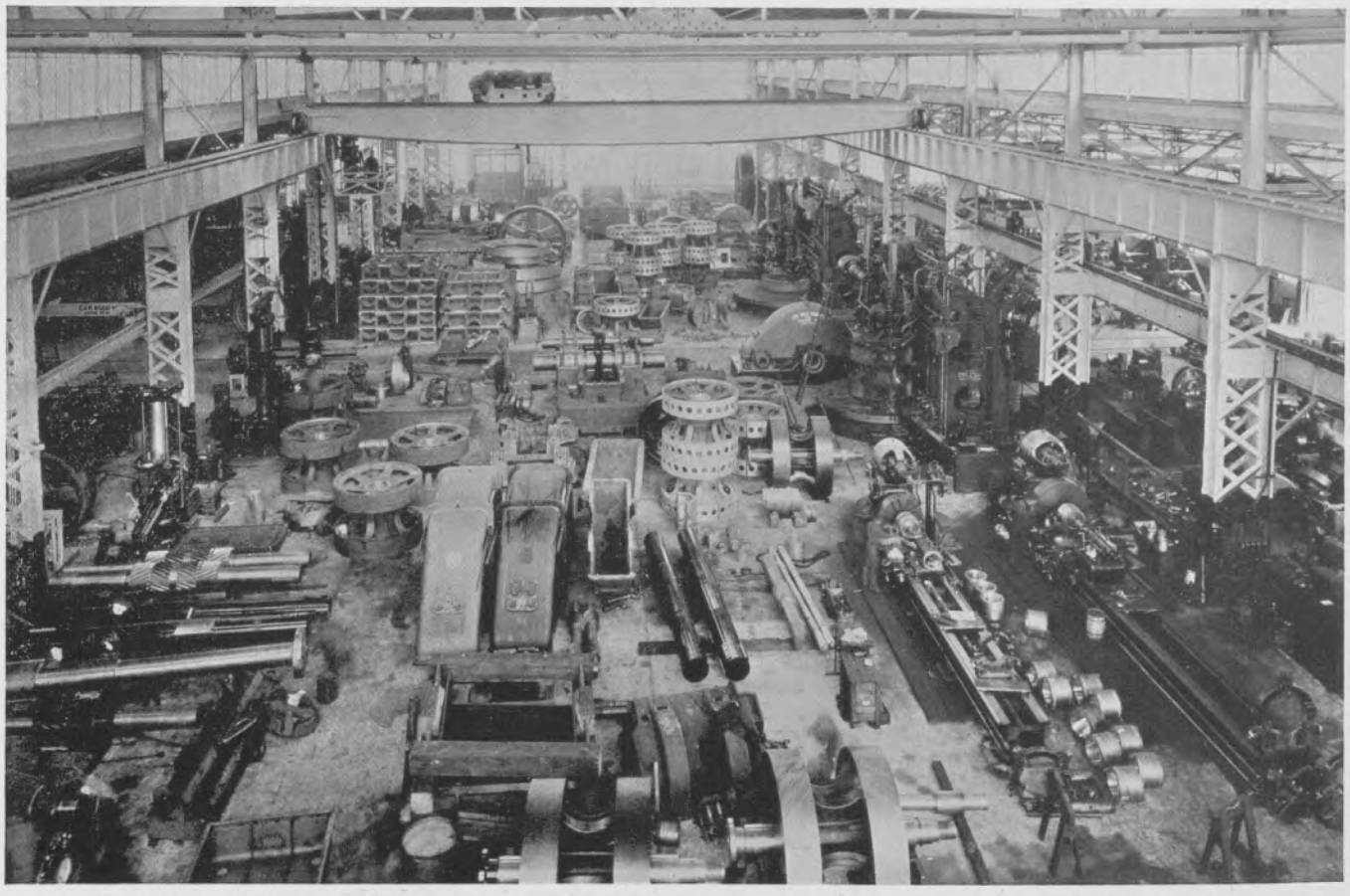


A number of assembled commercial reduction-gear units

engine, there are some characteristic differences in construction.

An illustration on a previous page shows a 3,000 h. p. turbine gear-unit for driving the propeller of a freighter at 90 r.p.m. from compound turbines at 3,600 r.p.m. This means a reduction of forty to one, requiring a double train of gears with five shafts and twelve bearings. The high-speed gears and bearings require forced lubrication and this system must be extended to the low-speed gears and bearings in order to avoid unnecessary complica-



No. 2 shop showing a number of gear units for United States destroyers in various stages of construction

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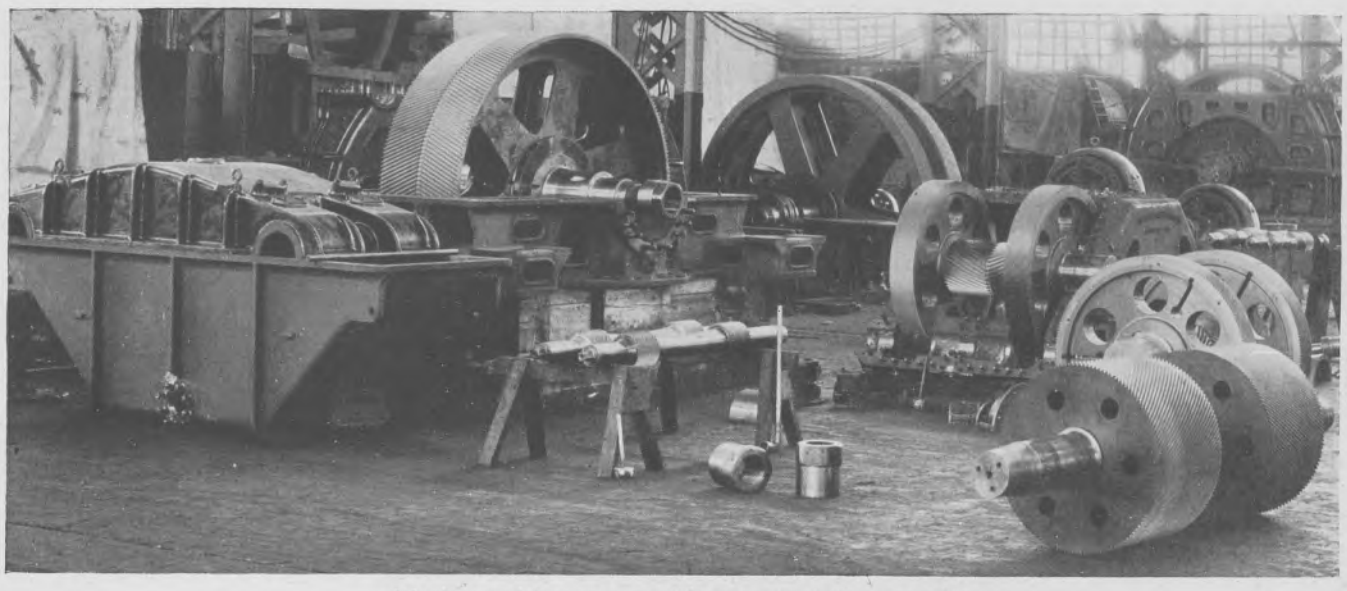
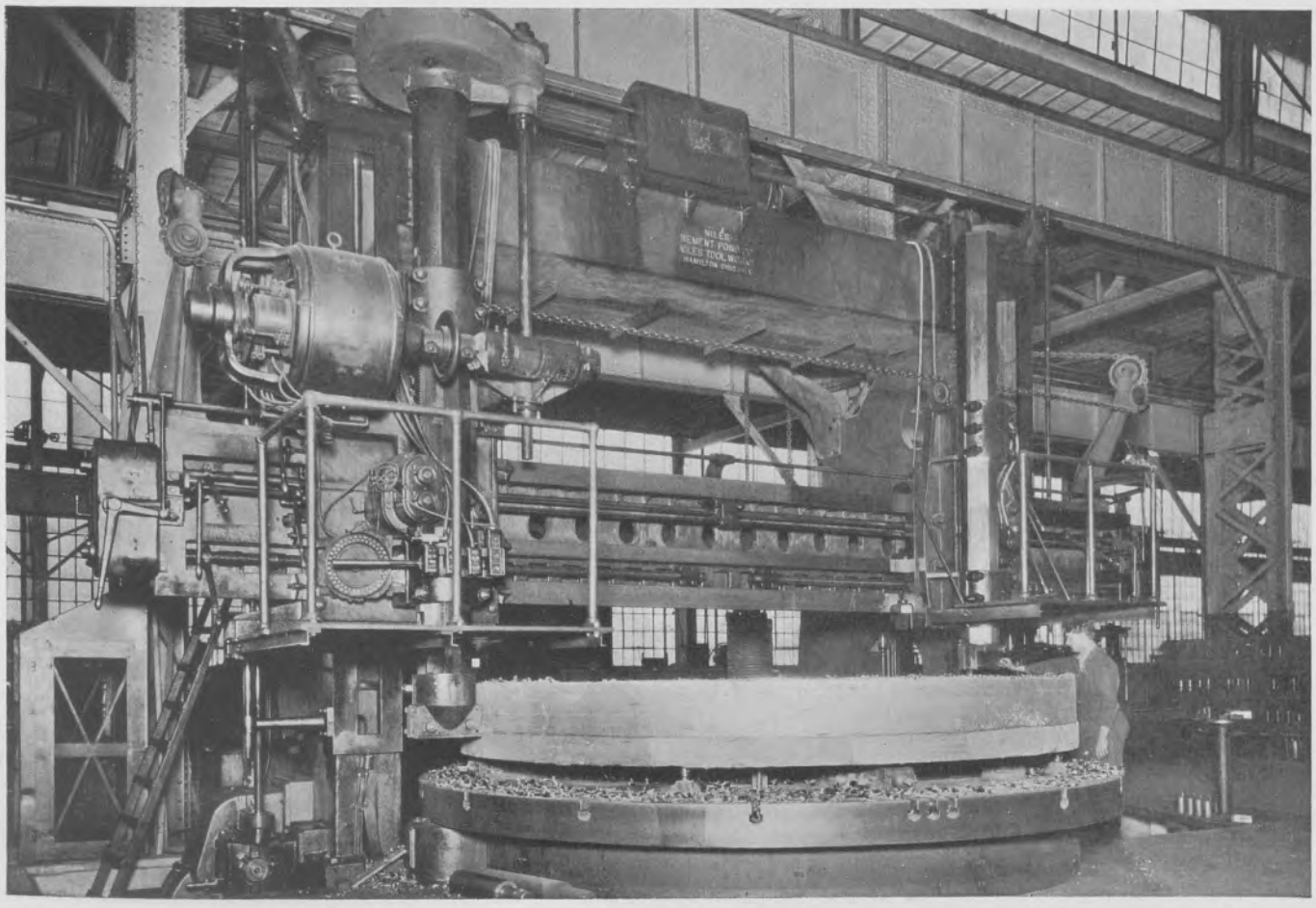


Marine turbine gears and frames ready for assembling

tions in the design and construction.

THE propeller shaft of a freighter usually runs at a speed between 70 and 100 r.p.m. and when geared oil-engines are used the gear ratio is rarely more than 2 or 3 to 1 with a maximum of 5 or 6 to 1 for small powers. Thus there are no high-speed shafts to be considered and the unit consists of a gear with one or two pinions, depending on the number of engines used.

UNDER such conditions forced lubrication is unnecessary. The bearings are of self-oiling type but are usually furnished with a continuous auxiliary feed and discharge without pressure. The gears operate at relatively slow speed, rarely more than 2,000 ft. per minute,



One of two Niles, Bement & Pond horizontal boring and turning mills of special design for machining large gear-blanks

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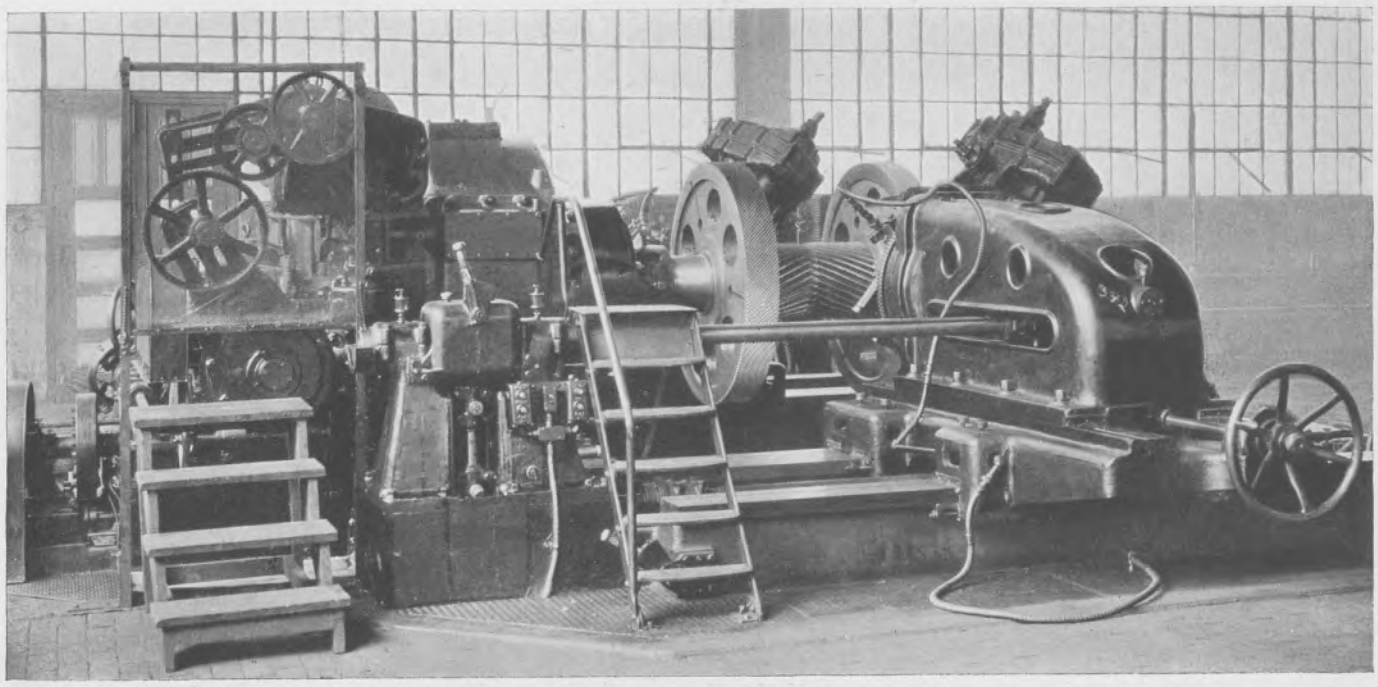
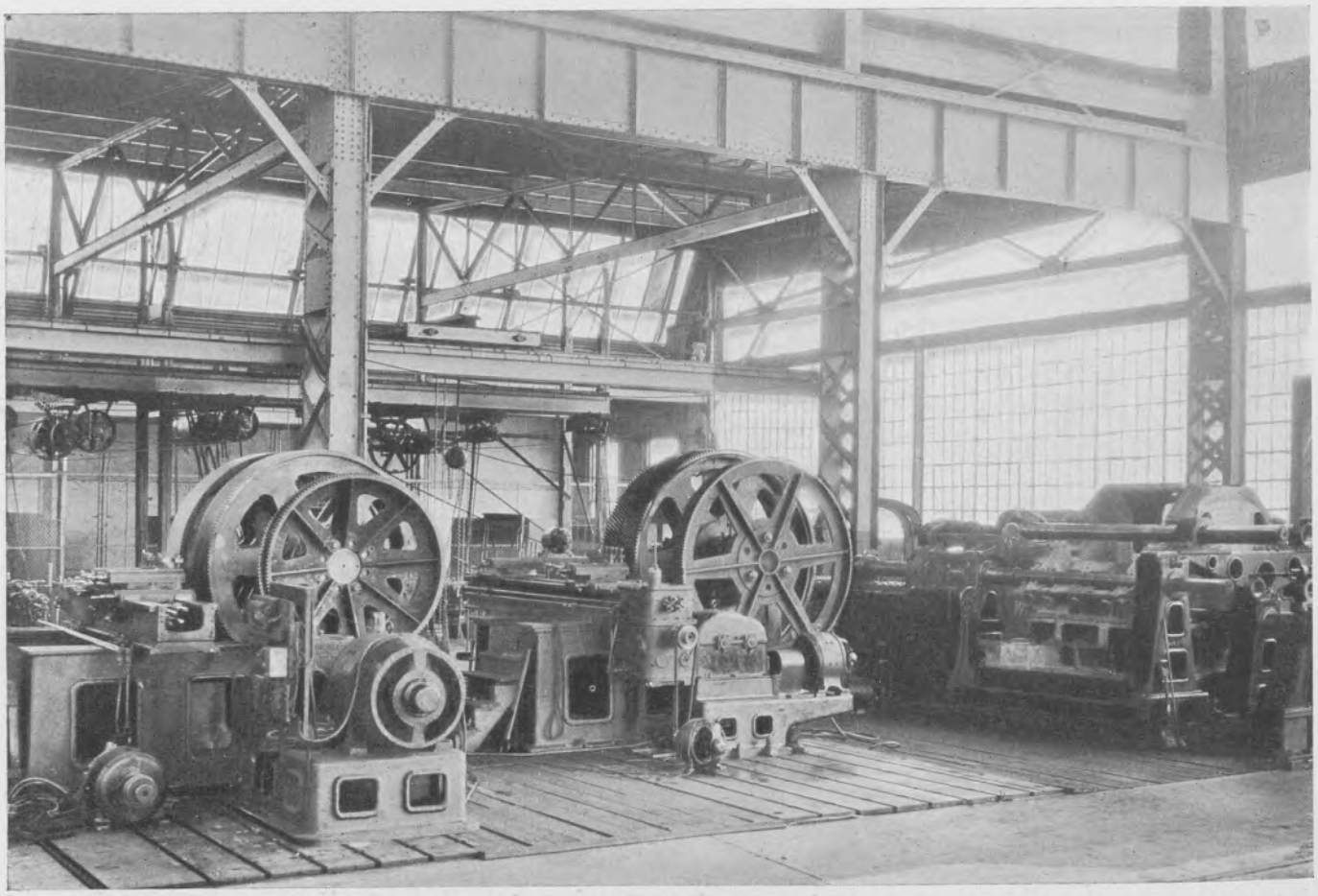


Machining the herring-bone teeth of a marine gear

and the teeth can be lubricated by immersion in a bath of semi-fluid lubricant contained in the bottom of the gear case. The viscosity of this lubricant is far higher than that of any oil that can be used with forced circulation and gives proportionately better protection to the gear teeth. It is for this reason that gears used in connection with oil engines operate with



Three interesting machines built at the Falk plant for special operations on gear units. In the foreground are two tools for truing marine-gear blanks on their own shafts. The other machine is a five-spindle horizontal boring bar for simultaneously boring the bearing seats in the frames

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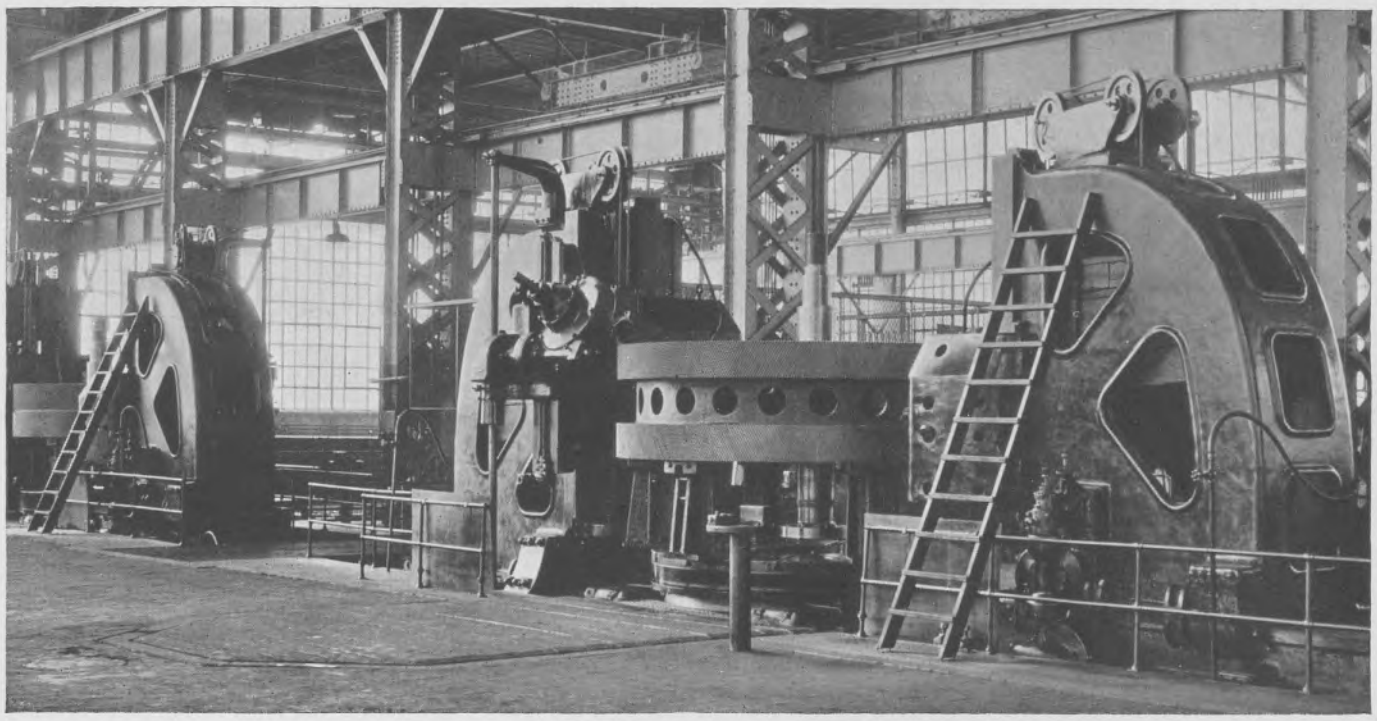
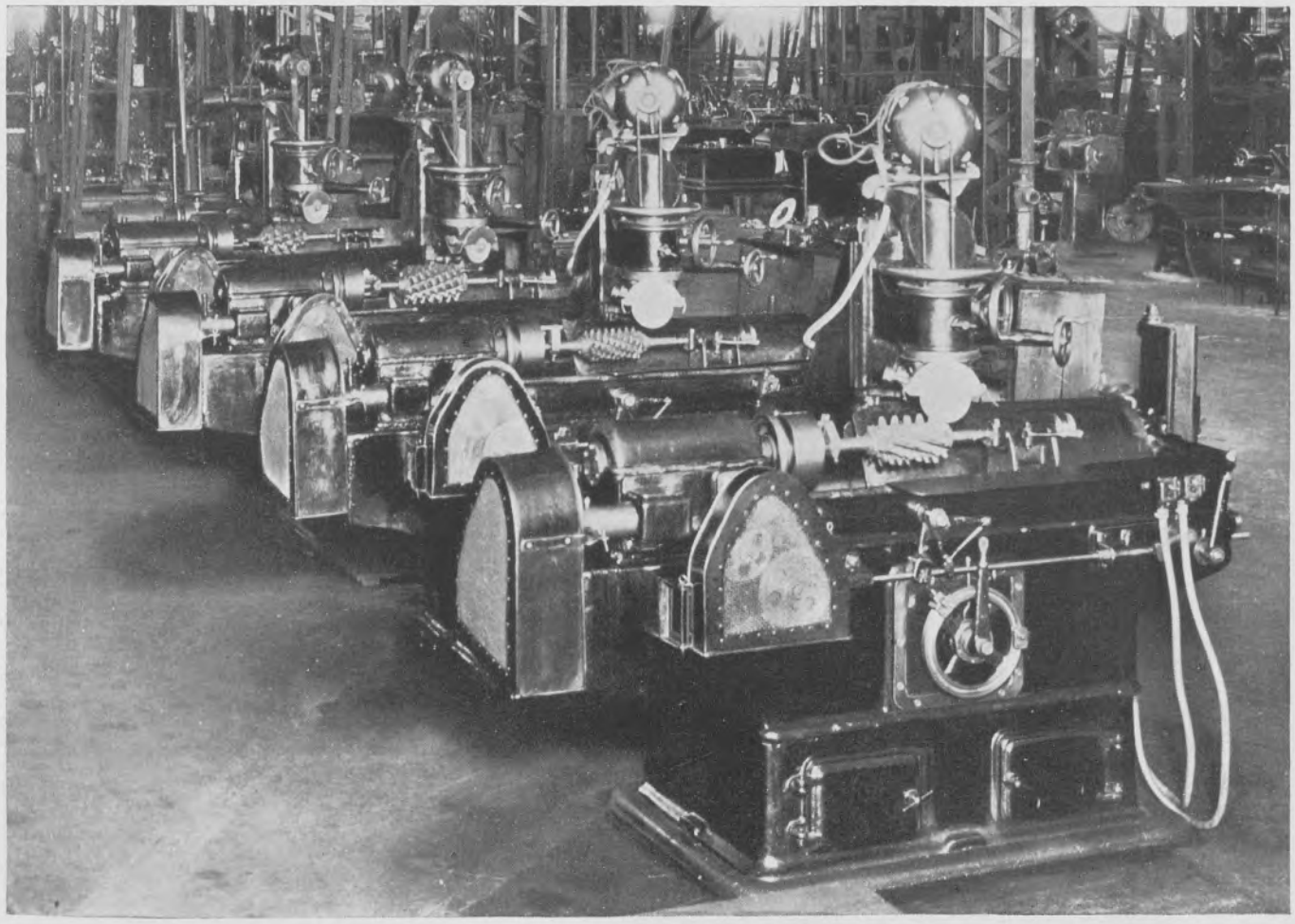


A pair of big gear-hobbers machining large marine turbine-gears

even less wear-and-tear than similar gears in turbine-driven ships where limitations in design make it necessary to use a lighter form of lubricant on the gear teeth as explained.

WHILE the problem of applying gears to a turbine-driven ship was a difficult one and



Automatic hob-grinding tools designed and built at the Falk plant

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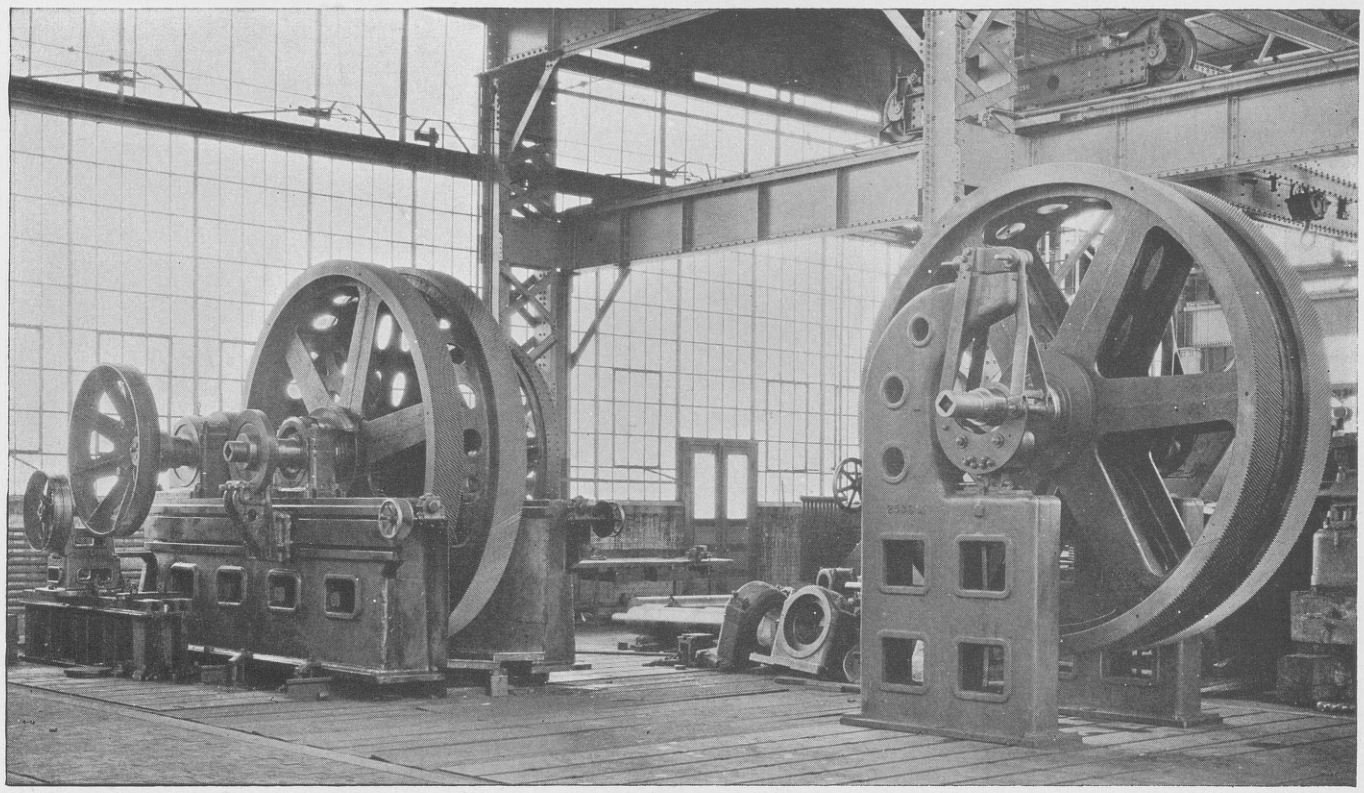

Testing and balancing marine gears in special machines

led to a great deal of costly development, there is no longer any problem in furnishing gears for oil-engines because it has already been solved for the much more difficult case of steam turbines.

In addition to reduction-gears for turbines and oil-engines The Falk Corporation specializes in steel gears for use for other purposes, particularly where service may be extraordinary on account of heavy loads, steep grades, high accelerative speed with frequent stops, etc. And, most satisfactory results have been attained in the making of solid gears of heavy design.

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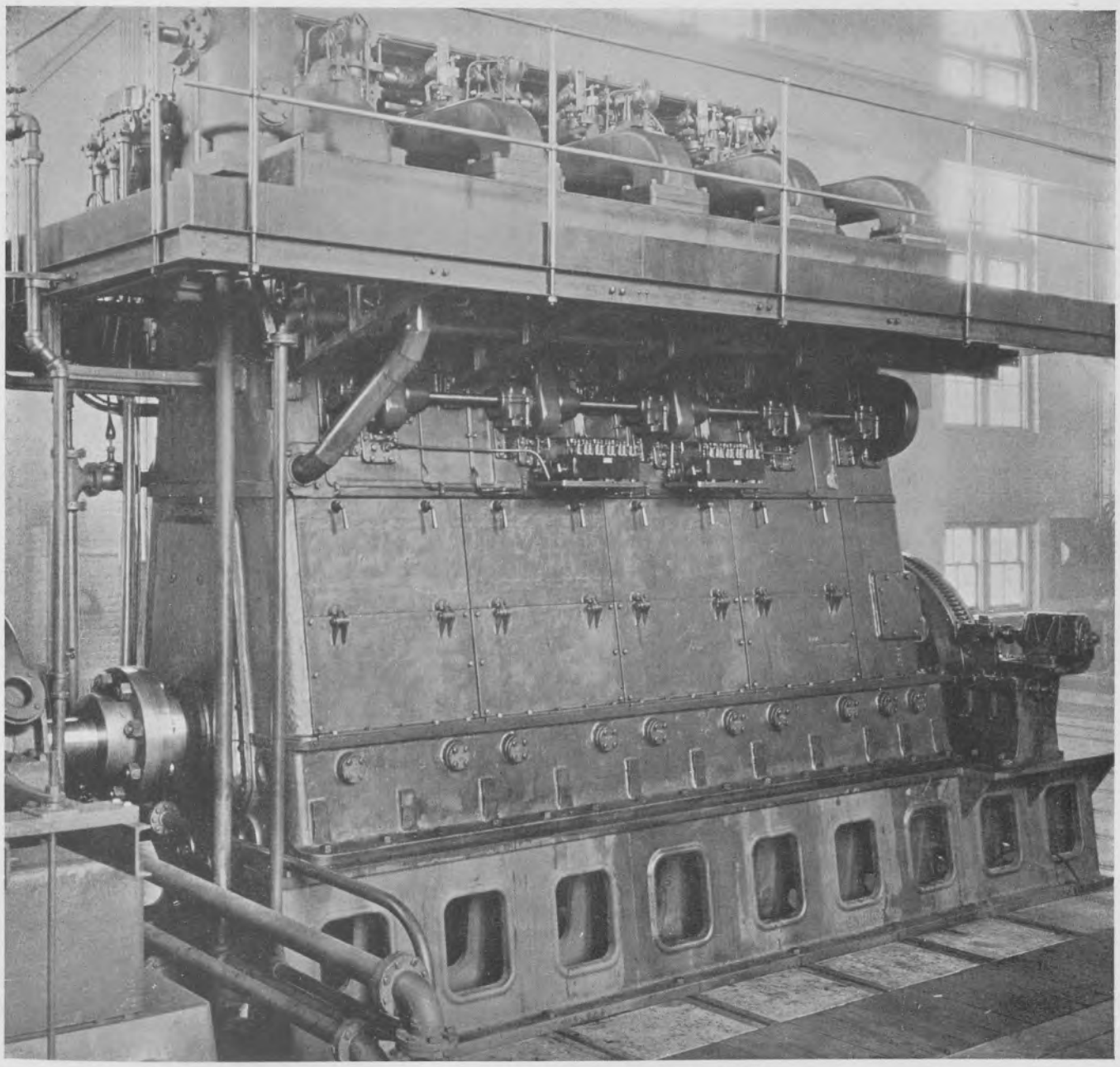
The Falk Heavy Oil-Engine

A Highly-Developed Power Unit for Reduction-Gear, Electric and Direct Marine Drives, and for Stationary Power Work

HAVING before them a remarkable record for building marine turbine reduction-gears it was only natural for The Falk Corporation to meet the immediate future demand by extending their plant's scope and construction to the marine oil-engine drive, which has already taken an important position in commercial and naval maritime affairs, and is rapidly growing into even greater prominence. Following most exhaustive investigation and consideration of every engineering and commercial factor involved, the Directors of the Company decided in November 1919 to take up the construction of oil-engines primarily for marine purposes. Many weighty reasons appeared obviously in favor of such a decision.

UP TO that time the propelling machinery of Diesel-driven motorships of large tonnage consisted almost exclusively of heavy, direct-coupled, crosshead engines which have had to be run at propeller speeds previously regarded



A Falk marine oil-engine of 550 b.h.p. at 200 R. P. M.

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as somewhat too high for the best efficiency with full-lined cargo vessels. Furthermore, by far the majority of existing motorships of over 1,000 horsepower had the twin-screw arrangement with the inherently higher constructional costs of both hull and machinery, as well as a bigger operating bill of a larger engine-room crew, than a single-screw ship of equal displacement and speed. These factors, of course, mean higher costs of maintenance and operation. Many steamship owners who adopted motor power preferred to "play safe" and insisted upon twin engines, but meanwhile looked forward to the time when they could with confidence order single-screw motorships in high powers.

In fact, the tendency in vogue internationally when the Falk directors were considering their question, was to increase the weight of the engines and simultaneously reduce the revolution speed, involving heavier and more costly machinery for single-screw and twin-screw plants. It also was doubtful if the rate of new ship construction would continue for long after 1919, making it desirable to consider the possibility that a reduction of building might already prevail by the time The Falk Corporation had developed an engine that was in every way satisfactory, in which event the engine might have been produced for a market that was restricted. This situation made it advisable to be in a position to meet a changed market and to consider possibilities offering themselves in the way of converting existing steamships to oil-engine drive as a field for the sale of the oil-engine. In the light of current developments it appears that this reasoning was correct.

The gear-drive for oil-engines was not new to the Company, for it had completed the installation of two sets of reduction-gears for oil-engined motorships and was satisfied that their performance and continuous general service were beyond reproach. These vessels are the sea-going freighters "James Timpson" and "Libby Maine," operating in Atlantic and Pacific waters respectively under American ownership.

There is a difficulty in the conversion of steam-turbine driven ships owing to the existing propeller-shaft diameters being too small for direct-coupled, slow-speed Diesel engines. Increasing these shafts in size means such considerable structural changes in the hull that the cost of conversion in all probability would be prohibitive in many cases. On the other hand there are a great number of older ships laid-up or in service, with reciprocating steam-machinery, the engines of which run at such low speeds that the usual direct-connected Diesel might be out of proportion, making their conversion also far too costly.

Aside from the new Falk reduction-gear system, the only machinery suitable for these two cases is the Diesel electric-drive, now being pushed very energetically by the builders of electric equipment. This dual-equipment is quite high priced, and its operating costs heavy because of the reduced overall efficiency, unless the oil-engines are run way above the revolutions advisable from a reliability aspect. The same holds true for hydraulic transmission, such as the Foettinger transformer. Consequently, the geared-Diesel drive seemed to offer the more reasonable and economical solution for steamer conversion problems.

With these important factors in mind it was decided in November, 1919, to design and build a complete 2,200 shaft horse-power gear-driven marine set. The thorough manner in which The Falk Corporation tackles problems is demonstrated in the program laid-out for this big undertaking at the outset. There was no attempt to "play" at oil-engine construction, or for the sake of the least possible financial outlay to adopt half-hearted measures, but the Firm proceeded in a thorough, engineering-like manner even although that course involved a huge investment. A most difficult task, namely coupling four large units to one gear and thus to one propeller-shaft, was at once undertaken, this gear to be coupled to a 2,200 b.h.p. electric generator in order to give the four units and gear nearly the same load conditions as at sea.

The switchboard was arranged for the generator to take the shop load or to be switched on a rheostat in order that the engines could be reversed and maneuvered as at sea, the generator substituting for the propeller resistance. This equipment, to be in

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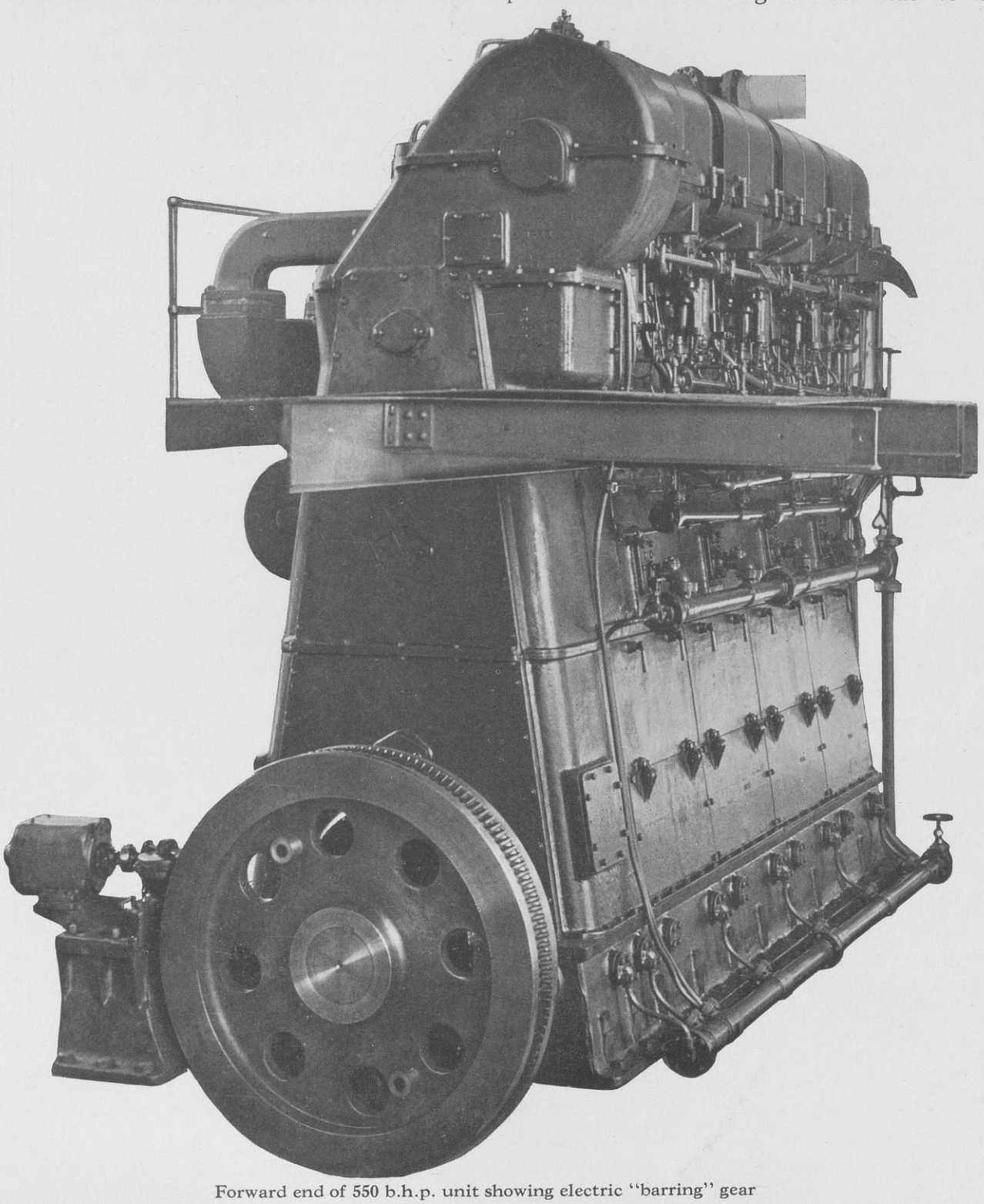
continuous operation at the Milwaukee plant, would furnish proof of its reliability, operating cost, etc., before placing the set on the market.

BECAUSE of the amount of other work crowding the shops, very little progress could be made with the oil-engines during 1920. But in 1921 work could be and was taken up with energy, with the result that early in September, 1921, the first four cylinder 550 b.h.p. unit was started-up under load on a water-brake constructed for the purpose. This brake was not used on the other engines.

AFTER the general decisions were made, the problem of the oil-engine itself had to be solved. The leading idea was to build an engine of utmost reliability and simplicity, an engine which in an emergency entrusted to new and inexperienced men would bring the ship into port under any and all circumstances.



Forward end of 550 b.h.p. unit showing electric "barring" gear

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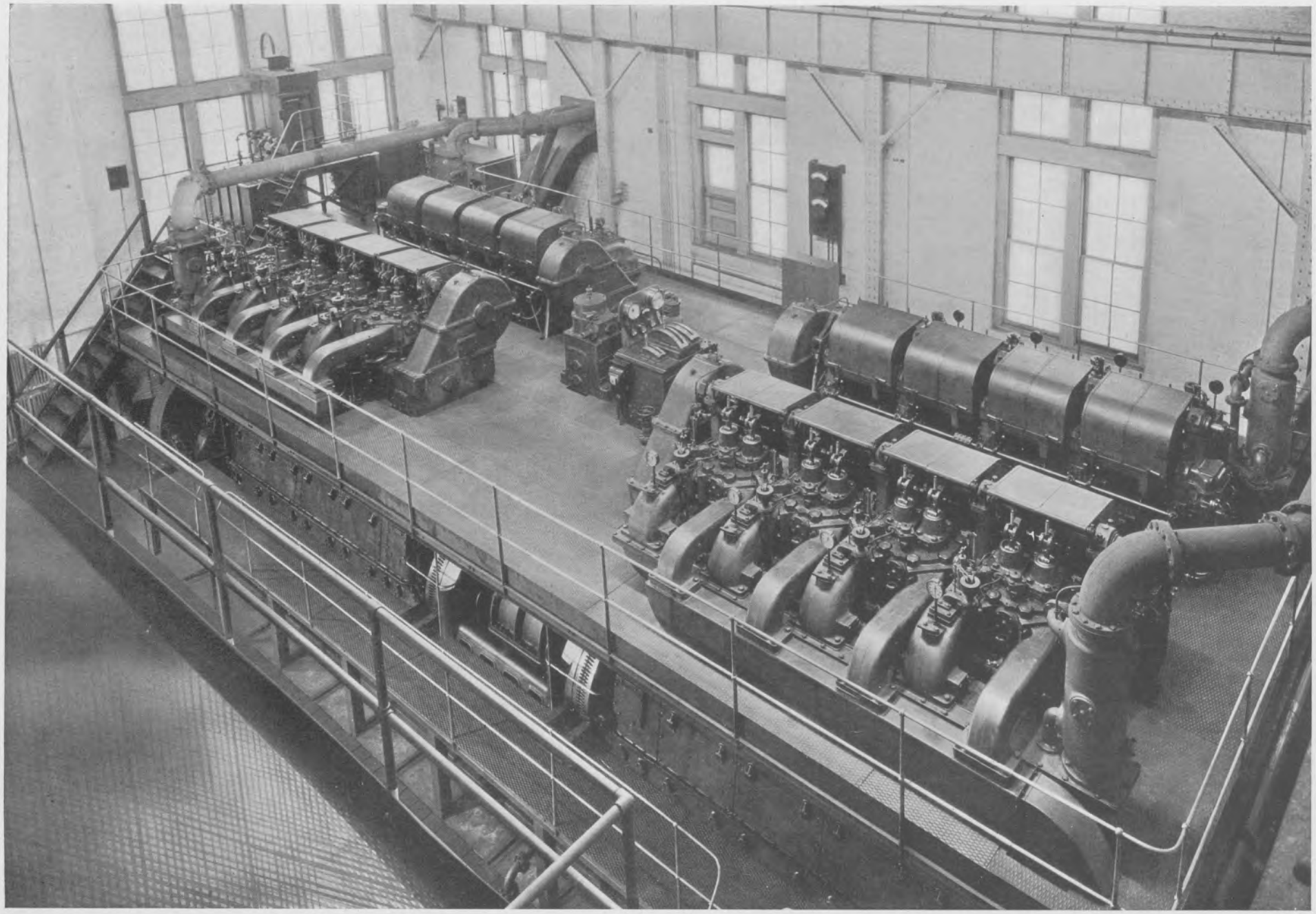

Bird's-eye view of the complete 2,200 shaft horsepower marine unit ready for installation in a ship's hull. Note central control on upper platform where the engineers are close by the valve mechanism and injection-system

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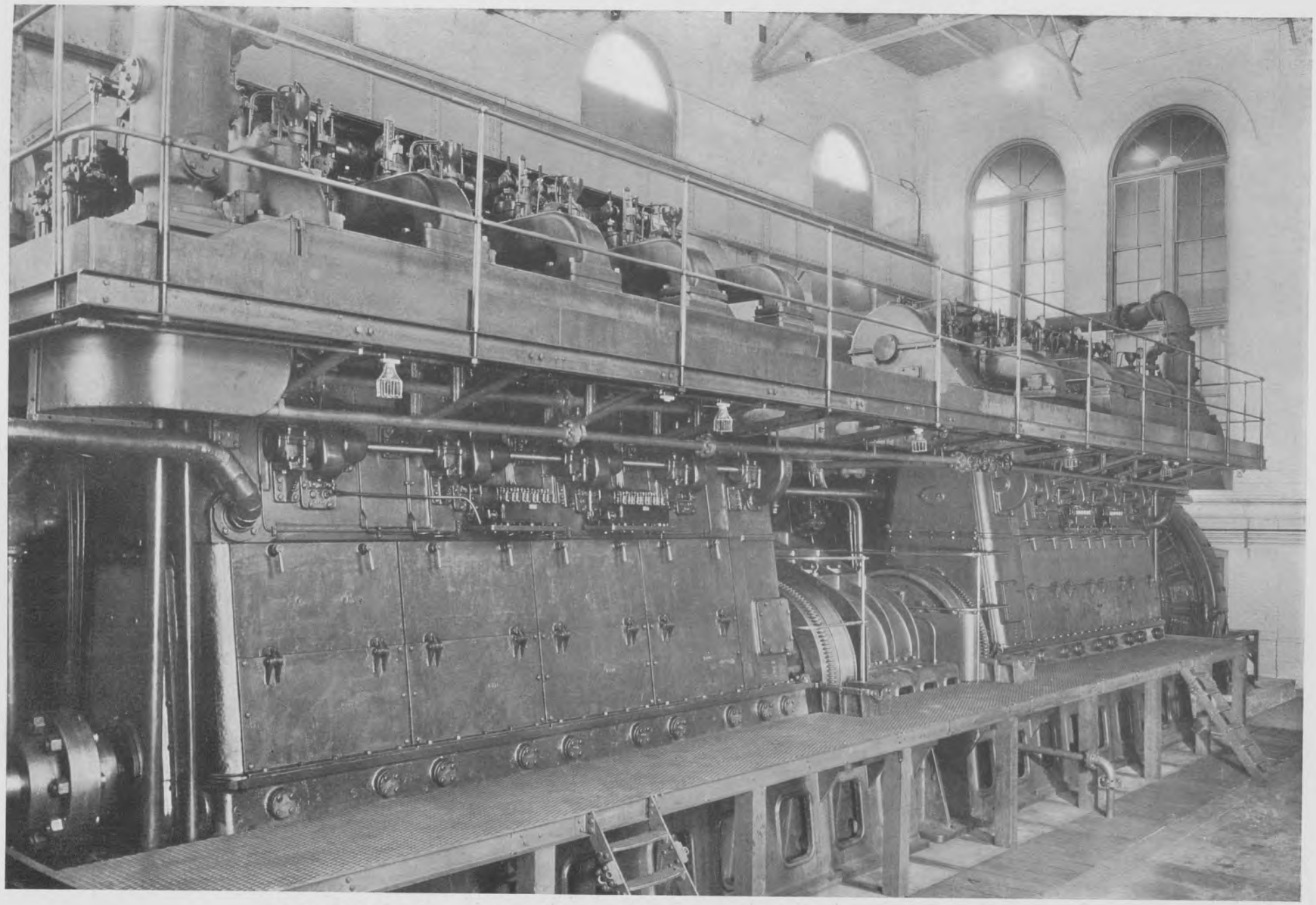

The four 550 b.h.p. Falk oil-engines in the power house at the Falk Corporation's works in Milwaukee

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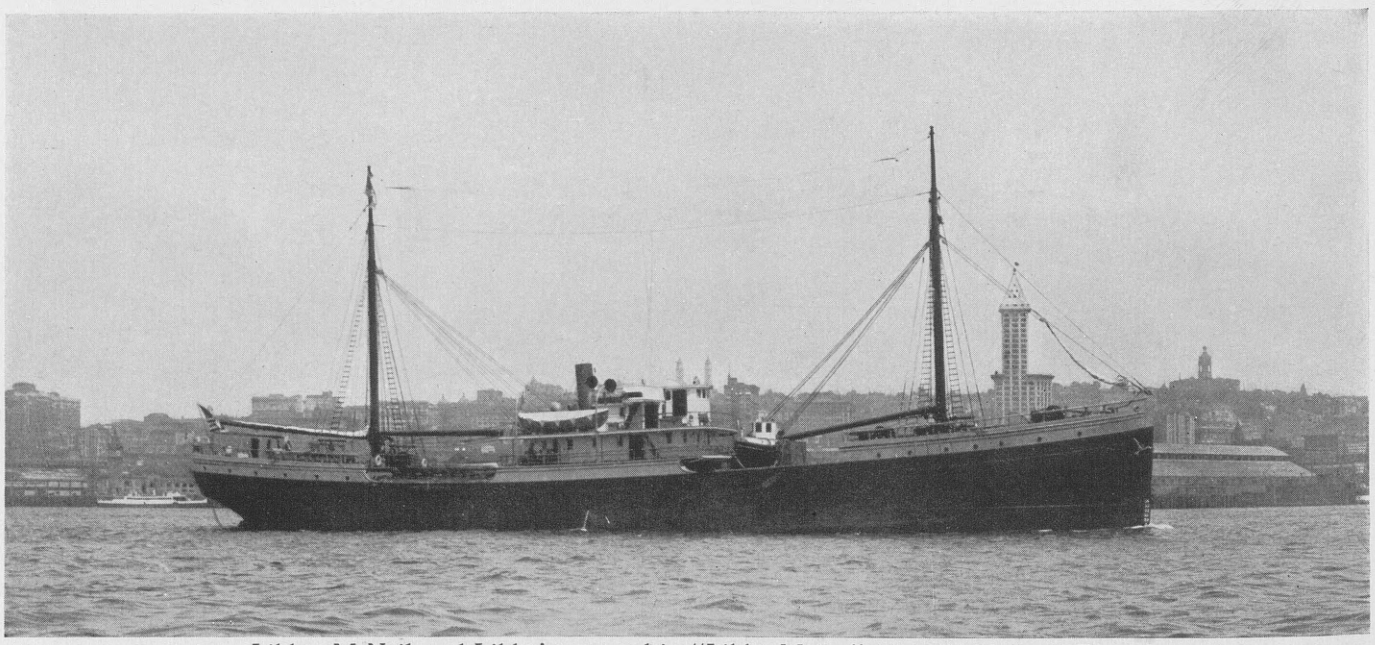
In the opinion of the Falk engineers such an engine should not be of the true Diesel cycle because of the air-compressor, spray-valves and their drives, air-pressure and timing control, high-pressure air-bottles and drains, and the interlocking mechanism of the spray-valves with the starting-air valves. Hence, a directly injecting pump spray, otherwise termed airless or solid injection system, was the only one considered for the purpose. Of this particular type the only high-powered engine which is generally conceded to have passed the experimental stage is a well-known British design. This in the opinion of the Falk engineers has a complicated injection control and is too sensitive for the service just outlined.

SINCE common sense demands that a ship propelled by heavy-oil engines should be able to bunker her fuel at any port in the world, it was necessary to build the Falk engine to burn the cheapest boiler fuels available wherever ships bunker. For such service the Diesel cycle is not considered by the Falk engineers to be so efficient as the combined Otto and Diesel cycles. Therefore, a cylinder-compression pressure of 350 lbs. per sq. inch and a maximum combustion pressure of 550 lbs. were adopted. A separate pump for direct injection to each cylinder was decided on. A closed combustion-chamber was preferred, which means that the cylinder space would be separated from the compression space by a water cooled plate, having an orifice affording communication between the two spaces. This arrangement gives an extremely simple injection system, insures clean, smokeless combustion, good fuel consumption, and low replacement cost when necessary.

ANOTHER great advantage of such a system is the resultant low temperature, permitting the use of uncooled pistons in larger cylinder sizes than with the true Diesel cycle. Utmost insistence was laid on this point, because an engine with cooled pistons was considered out of line with the program of simplicity laid down, due to additional complications that would have to be incorporated in the design. In order to be absolutely within the limits of safety the power per cylinder was limited to 138 b.h.p. Later experience has shown that this was over conservative for the adopted design and that the Falk designers had been scrupulously prudent.

THE most difficult parts of the design were the injection pump and spray nozzle. A test stand was rigged-up, and about the middle of 1920 an injection pump was put in operation. A very thorough research began, with the result that after about a year the absolute reliability of the sprayer ultimately produced was proven. Every injection pump that goes on an engine has been tested most thoroughly under pressures up to 10,000 lbs. per square inch, which is way beyond the working pressure.



Libby, McNeil and Libby's motorship "Libby Maine" propelled by two Dow Diesel-engines driving through Falk reduction gears

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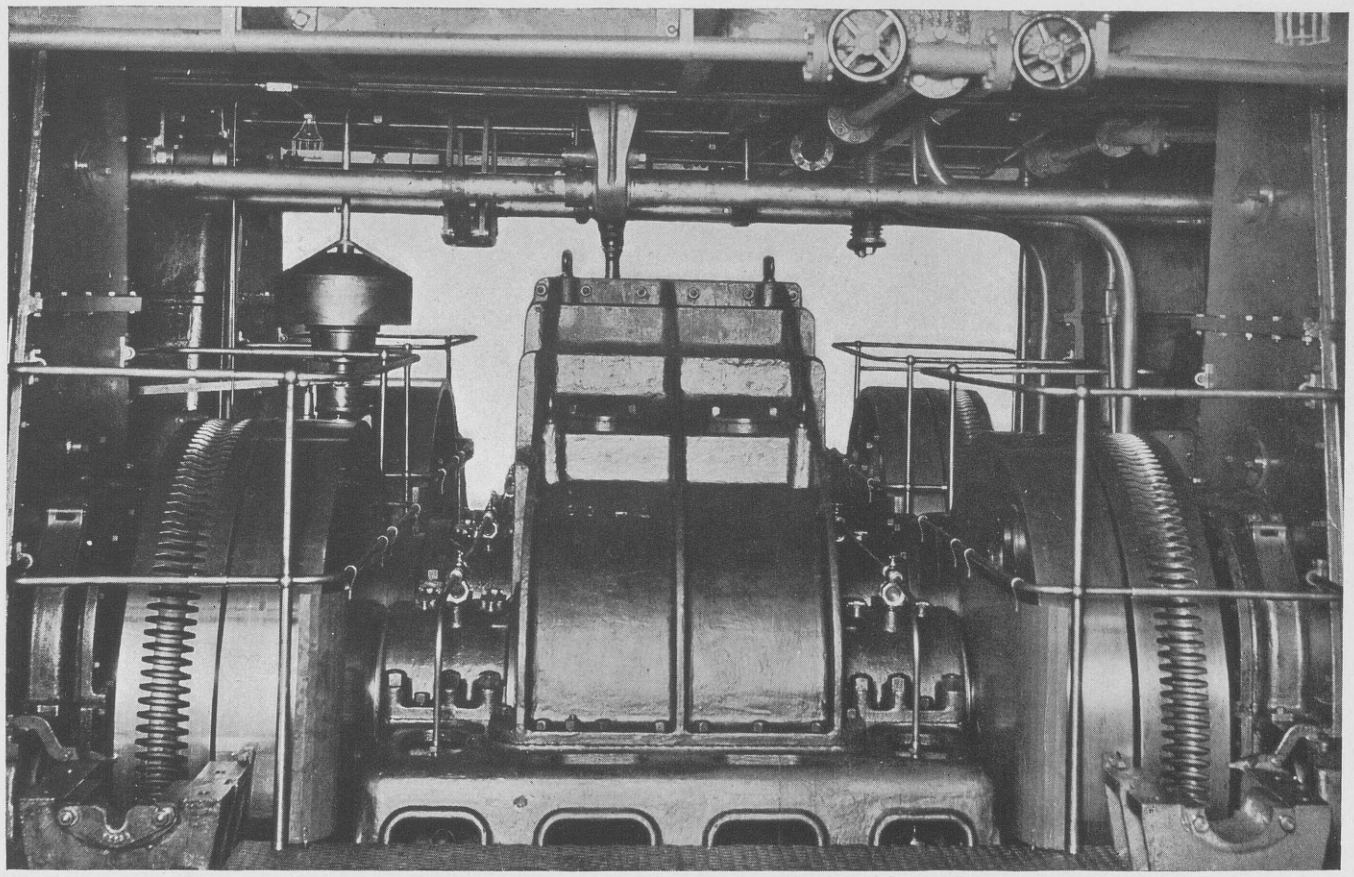

The Falk 2.22 to 1 herring-bone reduction gear between the four engines, giving a propeller speed of 90 R. P. M.

IT MAY be mentioned here that while the Falk engine does not conform to Dr. Diesel's cycle as outlined in his patents, it is a Diesel-type engine because it incorporates the famous inventor's main objective, namely, that of effective combustion through heat produced by compression of atmosphere.

THE shops of the Falk Corporation are ideally equipped with splendid machinery for producing the most accurately-cut gears imaginable. The shop force is in every respect up to its task. For years every possible way of improvement, along theoretical and practical lines, has been most carefully examined, and those which showed promise were worked-out with amazing patience and skill. The reward has been a reputation that reaches far beyond the frontiers of the United States. But the vast output had been confined to gears exclusively. When work on the Falk oil engine was started, it naturally was necessary to start out on entirely new lines, develop an entirely new practice and become used to entirely new lines of thought. The drawing-office has handed all the drawings to the foundries and shops with all the necessary tolerances exactly marked, kind of materials and treatment specified, so that the engine parts could be machined and assembled without any hitch. The work of both drawing-office and shop has been such that this is what has actually happened. The first unit was assembled, started, and operated without further adjustment of any part, not even the valve settings. The three following units making the complete set of four engines, came up to this record in exactly the same manner.

BEFORE going into details of the engine units, it may be well to point out that these have been designed especially for the reduction-gear drive. The main question in this respect is that of their speed. The higher this is chosen the smaller, lighter and cheaper the resultant whole unit. The limit of speed is the light-weight submarine engine type. But it was decided not to go to such extremes; on the contrary, the engines were laid-out for the conservative speed of 200 revolutions per minute. Incidentally, the units also conform to the lines of the most approved practice of land power-plant design, for which purposes they also will be used. As it happens, the

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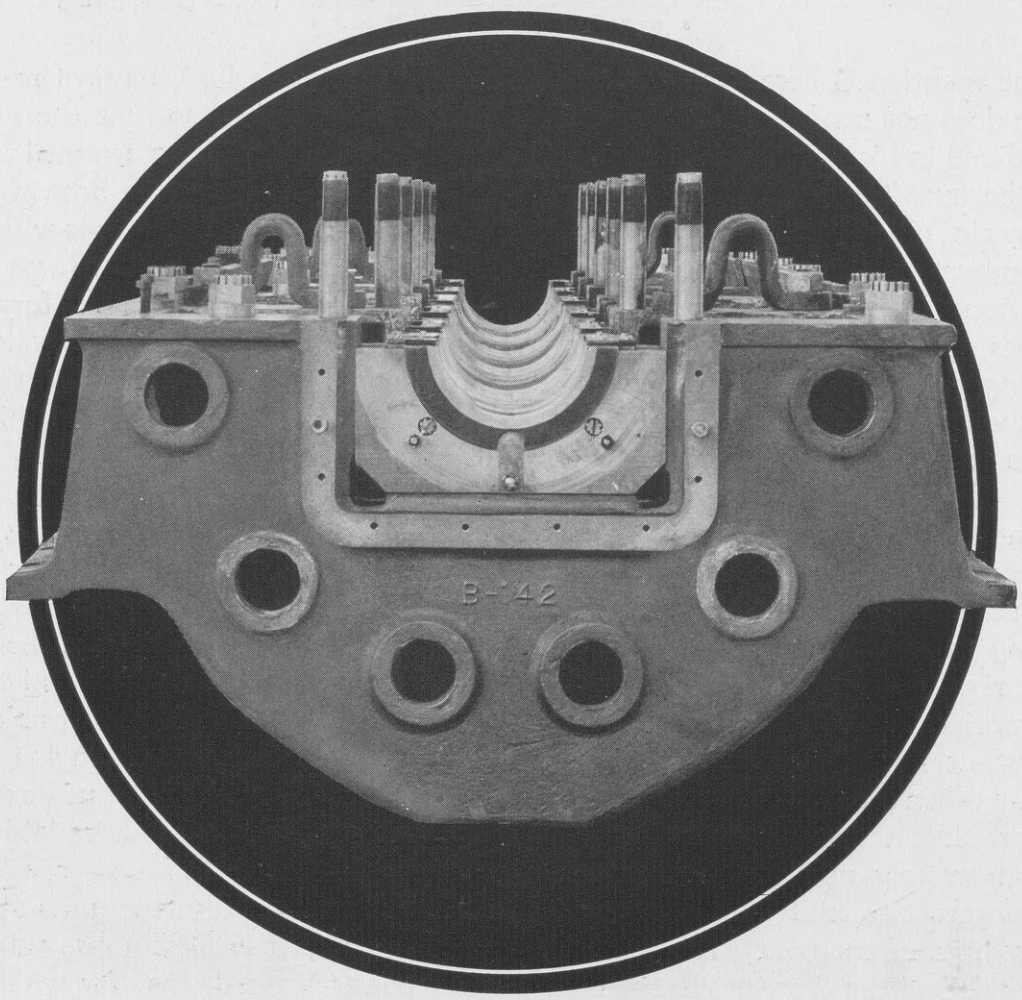
design, weight and speed renders the engine ideal for electric-drive, and for direct drive with many types of coastwise craft and large yachts where a propeller speed of about 200 r.p.m. is desired. Their weight is moderate, being 227 lbs. per horse-power including platforms, intake and exhaust manifolds, etc. But, in every instance weight-saving has been sacrificed to rigidity, accessibility, ease of manœuvering, overhauling and inspection. Very ample provision has been made to obviate corrosion by the sea-water used for cooling, and every water jacket is accessible for cleaning.

FOLLOWING the very latest motorship practice, the control station of the engine is on the upper platform above the main gear where the engineer-on-watch is conveniently near the valve mechanism. It was considered that the common reversing-gear, which consists of devices to lift the rollers of the valve drive off the cams, shift the camshaft and then lower the rollers on the reverse cams, was too complicated, so a new and exceedingly simple reversing mechanism has been incorporated. This gear permits the use of a centralized reversing device with electric operation, and by means of two shafts and a few levers simultaneous reversal of the four units is effected in a very simple way.

IT WAS thought that an engine of this size would only be used in conjunction with "all-electric" auxiliaries, in as far as the ship's engine-room and deck auxiliary machinery was concerned, therefore, the reversing machine, barring-gear, lubricating-oil pumps, water-cooling pumps and the starting-air compressor are all electrically driven.



End view of bed-plate showing construction of main bearings

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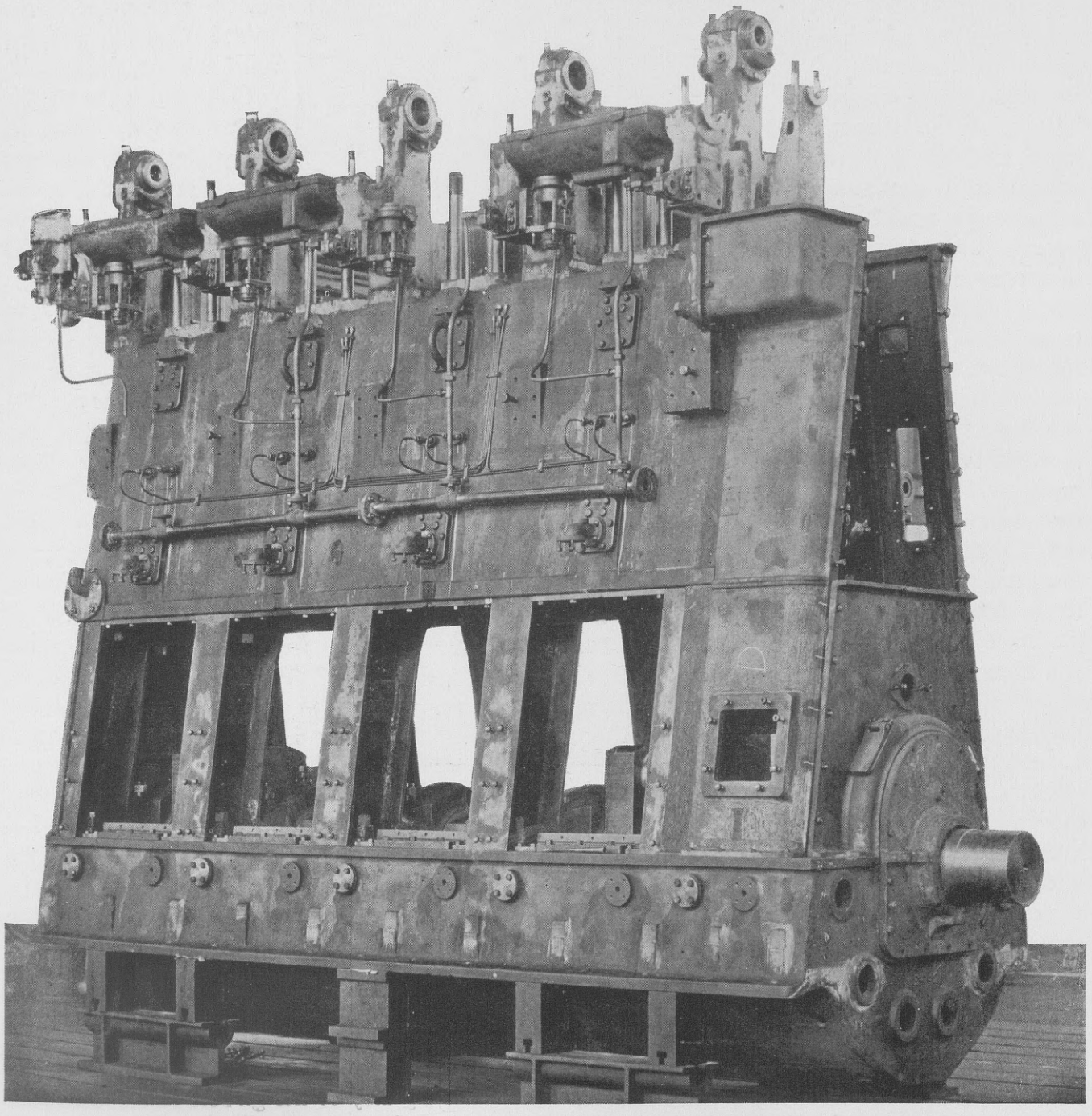
Details of the Design

A Discussion of the Various Constructional Features of the Falk Oil-Engine

A PROPELLER shaft speed of 90 r. p. m. having been selected, the gear ratio was fixed at 1 to 2.2 by the fact that the engine units turned at 200 r. p. m. This engine speed in turn was fixed by the adoption of the largest diameter of cylinders in which water-cooled pistons could be dispensed with, namely 19", and with a stroke ratio of about 1.5 regarded as the best practice for units of this character a piston travel of 28" was produced. Each unit engine has four cylinders and thus develops 550 b. h. p. The whole group is rated at 2200 b. h. p. at normal speed. Complete general arrangement and sectional drawings are given on the folding plates bound inside the back cover of the Supplement.



The sound engineering practice incorporated in the Falk design is clearly depicted in this illustration of the 550 b. h. p. engine partly assembled

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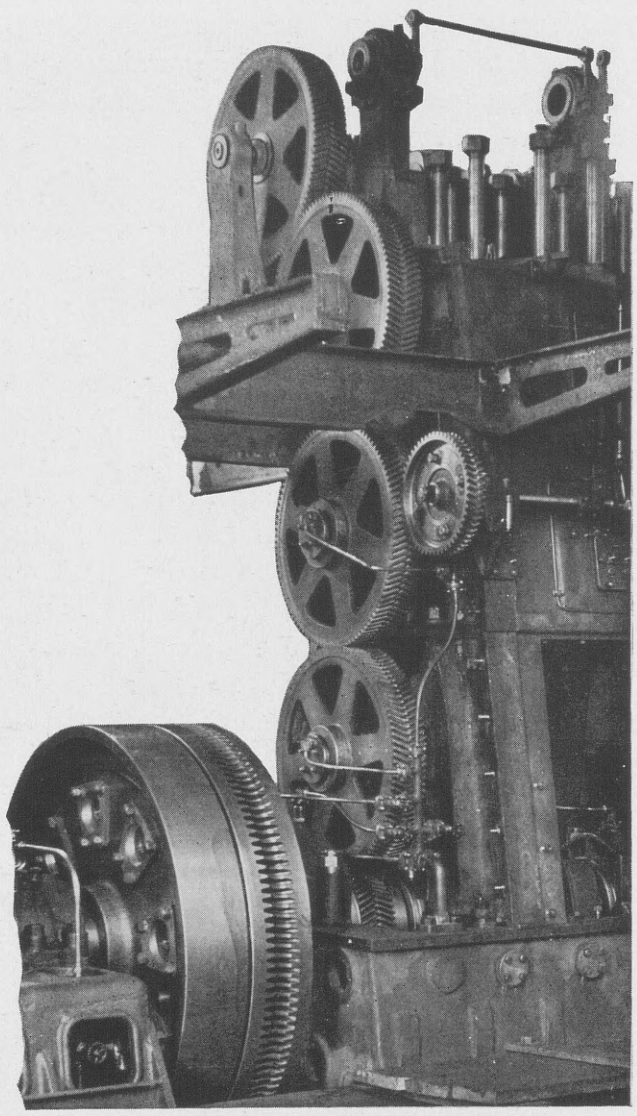
In detail of design the four unit engines are identical, but in general arrangement they differ slightly on account of the symmetry desired in the group for general convenience of control. Thus, for instance, the starting-air boxes are fitted at the free end of each camshaft and the camshafts adjoin the center line of the group. In this way the combination of the control of all four engines can be disposed in the simplest and most effective way at the center of the group on the upper platform, above the main gear.

Engines of this speed are naturally of the box-crankcase type. The Falk engineers have utilized the box design to the utmost advantage and have given it a combination of strength and accessibility which could not be excelled. On top of the bedplate is a cast-steel column housing surmounted by a tank in which the cylinders are held. The sides of the bedplate, column housing and tank form a clear straight profile from top to bottom. Eight bolts transmit the thrust of the cylinder cover to the tank top, and the stress is carried down through a well devised system of ribs and plates to I-beams which extend across the lower tank plate between cylinders. These I-beams are bolted to the housing columns which also are of I-section and straddle the main bearings. This design takes care of the stresses in such excellent manner that there is a noticeable absence of vibration in the framing. The rigidity of the structure has even been very marked when the engine has been run under abnormally high pressures for experimental purposes.



Showing train of gears for camshaft drive

Unlike the housing columns which are of cast-steel, the cylinder tank is of cast-iron, serving not only to transmit the thrusts from the cylinder covers to the columns, but acting also as a jacket around the cylinder liners. The liners fit on a shoulder in the tank top and are allowed free expansion downward. Where they pass through the bottom of the tank they are packed in a stuffing-box to insure against leakage of water into the crank-pit. To help support them against the side thrust of the piston there is a plate extending from end to end of the tank at about middle height in which they make an easy fit. This center plate serves the additional purpose of carrying the Monel-metal tubes for the piston lubrication.

Both sides of the column housing can be stripped practically wide-open owing to the provision of exceedingly large doors. When inspection only, and not access is desired, the upper halves of the doors, which are of aluminum, can be swung open. The upper halves are pinned to the lower halves and held closed by handles. When the entire door is removed there is an opening extending the full width between columns and the full height between the base plate and the tank, thus furnishing access to the running parts with the fullest possible measure of comfort and convenience.

A single baseplate is used for each engine. It is well and strongly ribbed with particular attention paid to the stiffness of the side beams and the rigidity of the girders under the main bearings, of which there are five, with a thrust

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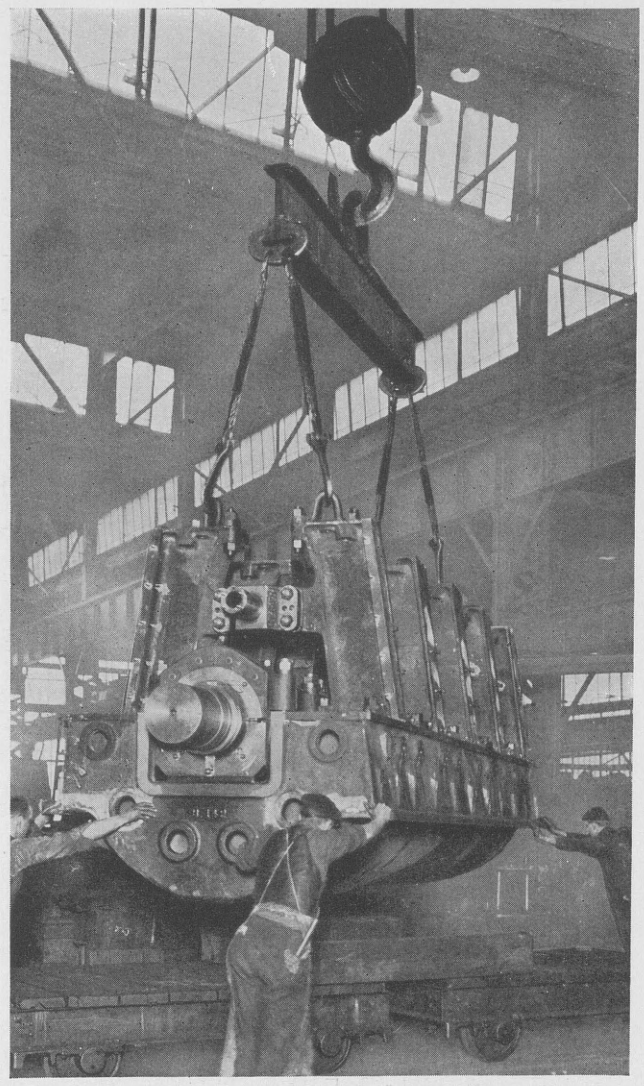
bearing in addition at the coupling end of the engine.

MARINE engine practice is shown in the bearings. The shells are made of cast-steel which are babbitted and lie on cast-steel saddles on which they can be rolled out, but means have been provided to prevent them being rolled out when the shaft is barred over for inspection with the bearing covers removed. The thrust bearing has adjustable shells for taking up wear. Its incorporation in the design is to prevent the shaft from moving endwise, either alone or in unison with the gear pinion of the main drive, which must be allowed to float since the low-speed gear is held in place by the Kingsbury thrust-bearing on the main shaft. Gear and pinions are interlocked by the herringbone teeth on their peripheries.



An idea of the frame and bedplate construction can be obtained from this picture

FOR a crank shaft of the size required in an engine of this power, the diameter being 11½", a single forged piece is the best-practice, particularly so in view of the fact that the cranks are all in one plane, the two outer ones being set at 180 degrees to the two inner ones. The dimensions and material are in accordance with Lloyds requirements.

WITH the cranks all in one plane, the firing order being 1—2—4—3 for ahead and 1—3—4—2 for astern, a four-cylinder 4-cycle engine could very seldom be started under air pressure. Two engines, however, would always start, and a group of four engines starts very readily. Tests at the Falk plant have shown that the group reverses not only with three or four units connected to the reduction-gear, but also on every occasion when only two engines are connected.

THE connecting-rods are of the usual marine type and the pistons of the orthodox trunk design with six packing-rings and one scraper-ring. Right up through the connecting-rods a channel is drilled to carry the lubricating oil from the crank-pin to the piston-pin bearing. The oil reaches the crank pin by a duct drilled through the crank-cheek and shaft journal, the main supply for each crank-throw being fed to the main bearings through the bearing caps. Splash plates, reinforced by angles, cover the crank-throws and prevent lubricating oil being flung up to the cylinder walls. The crank-case is of course oil-tight and there is no seepage at the doors. To prevent oil oozing at the coupling end of the shaft there are thrower rings, but these are not required at the free end of the shaft because it does not protrude from the base-plate.

IN the design of cylinder-head and combustion-space a considerable departure has been made from ordinary practice. Though the arrangement adopted is uncommon it is based upon a common-sense consideration of the combustion conditions. Something of the same sort has previously been used by one of the most experienced firms in Europe. Essentially the distinction between the Falk arrangement and standard practice is the addition of a water-cooled heat-shield between the cylinder-head proper and the upper part of the cylinder. The head proper is similar to that of the

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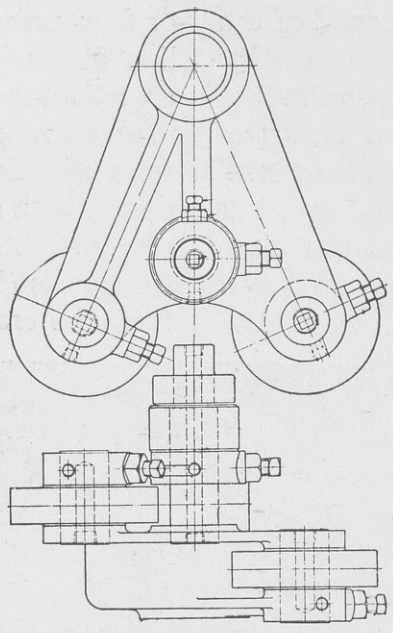
ordinary Diesel engine. It contains the inlet-valve, exhaust-valve, starting-valve and relief-valve, arranged symmetrically with clear cooling spaces around each valve chamber.

THE fuel sprays, of which there are two for each cylinder, are fitted horizontally into the heat-shield, diametrically opposite each other, directly under the inlet valve and exhaust valve of the cylinder cover. A flat recessed chamber is provided in the heat-shield where these sprays enter and the two streams of incoming atomized fuel impinge upon each other directly over the central bore of the heat-shield, which is in communication with the upper part of the cylinder and forms part of the combustion space.

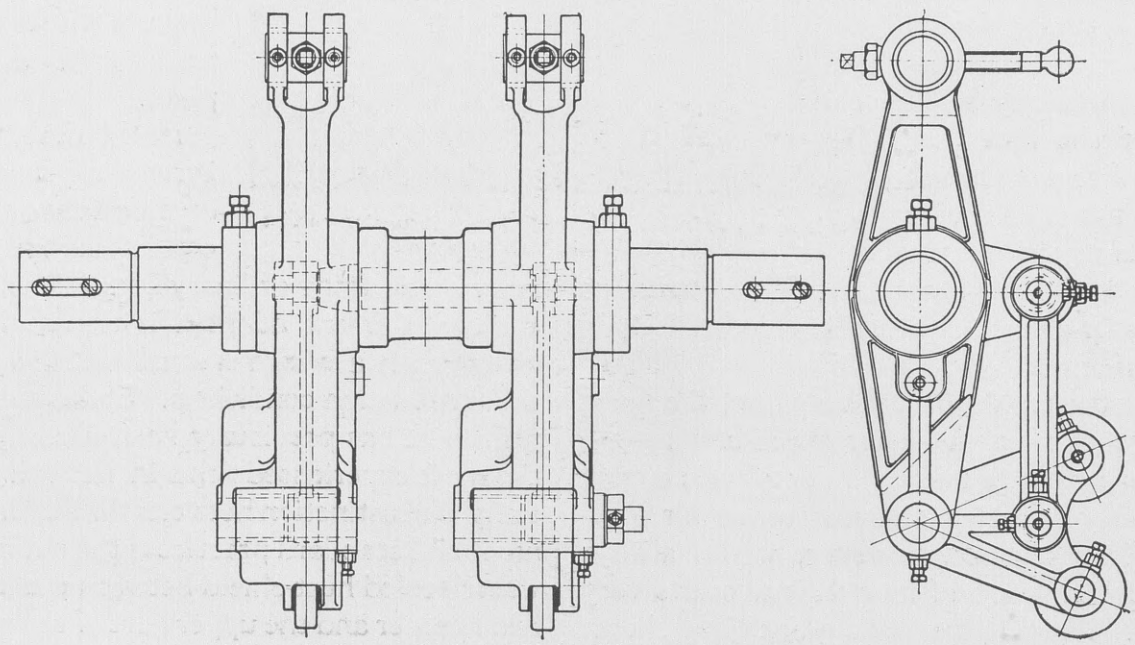


Triangle with Cam Rollers

IT IS to be noted that this style of design provides thorough cooling to the walls of the combustion-chamber where the greatest heat occurs. In the cylinder-head proper, for instance, right over the center line of the cylinders where in ordinary Diesel engine practice an injection valve is placed, there is in the Falk arrangement a water-cooled surface. Again all over the heat-shield the walls are adequately cooled. The piston also derives a benefit from this design because the flame does not impinge upon it directly in a concentrated cone, but spreads out over it at a lower temperature and in contact with a larger radiating surface.

VERY thorough water cooling is provided for the cages of the inlet and exhaust valves, the water entering on one side of the cage, passing around the valve seat and leaving on the other side. The valves themselves are not directly cooled by water. The inlet and exhaust valves are of course interchangeable. The starting-valve and relief-valves are made of a non-rusting alloy of steel-like qualities and are contained in bronze cages.

A SPRAY pressure of 3,000 lbs. per square inch is used for Diesel fuel-oil, but this is increased to 4,000 lbs. when heavy residual oils are used without preheating. The heaviest oils, like Mexican reduced boiler-fuel oil, must, however, be preheated before they can be used even at 4,000 lbs. per square inch. The sprayer pipes and pipe fittings are of steel with a very big margin of strength. During the trials made with the engines no trouble whatever has been experienced with them, although for experimental purposes they have been subjected to abuse.



Fulcrum shaft and Valve-Levers of one cylinder

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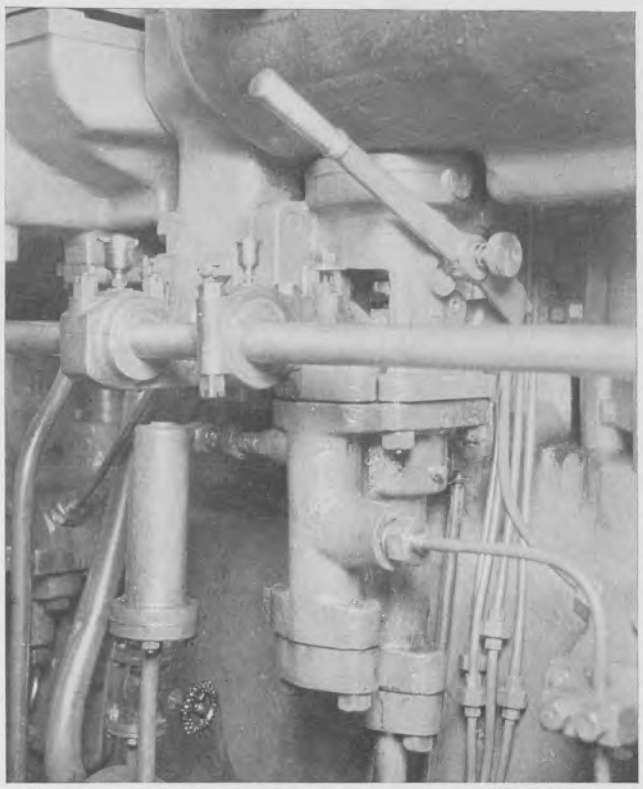
No external mechanism is required for the type of sprayer adopted, the delivery pressure of the fuel from the pump determining the start and finish of the injection, and the setting of the fuel-pump cam determining the time at which injection begins. From the absence of external mechanism is derived not merely a simplification of the overhead valve-gear, but also the corollary of a very much simplified reversing arrangement.

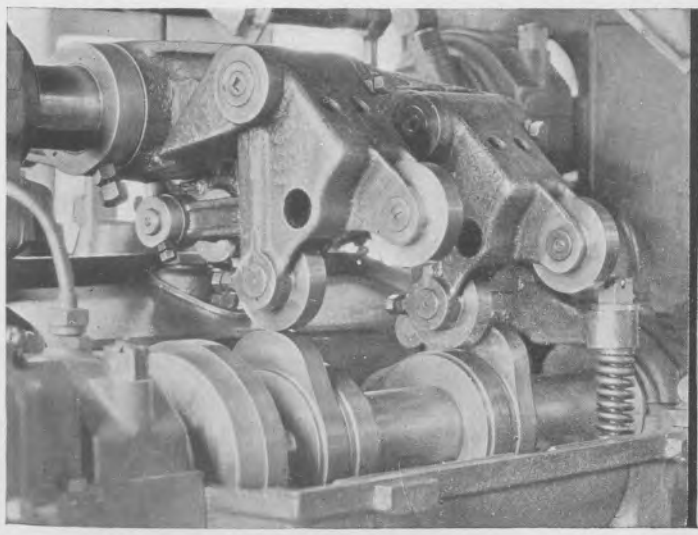


One of the individual fuel-pumps for each cylinder

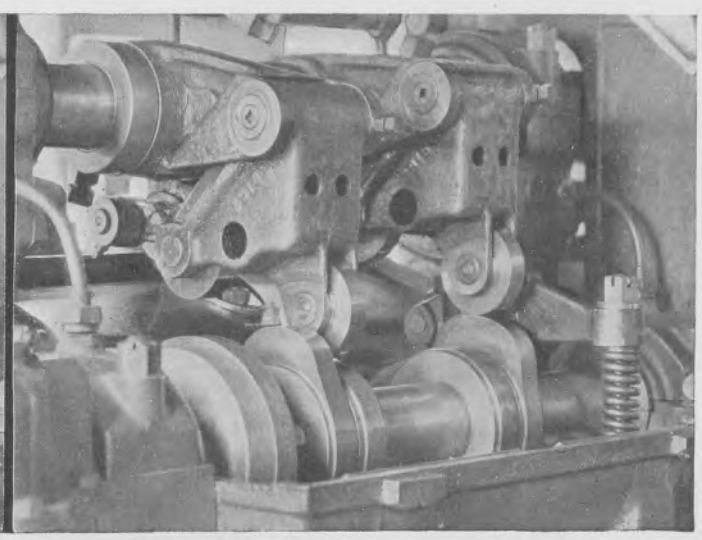
When this is considered in conjunction with the absence of the air-compressor, one cannot fail to be struck by the advance which the Falk engineers have made towards the ultimate goal of absolute simplicity which represents the ideal design from the maintenance point of view. To have made this progress, without sacrifice of efficiency, represents a considerable achievement.

It is through such economies of engine construction, manifested many times over, that the grouping of the four engine sets in one unit with a single reduction-gear has been rendered not only economical in first cost, but assuredly economical also in maintenance. It is clear, furthermore, that the duties of the engine-room watch are not increased when the engines are so greatly simplified even if the number of sprays are doubled by the adoption in this design of two per cylinder. Even so, the total number of working parts belonging to the injection system of each Falk cylinder is less than with an ordinary mechanically operated fuel-valve, whether of the airless type or of the more common air-blast type. There is the additional advantage also that one can rely upon the regular inspection of important working parts that are simple, whereas those same parts if incorporated in a more intricate mechanism are apt to receive less attention.

The nozzles are simple plugs into which a number of spray holes have been drilled. These Falk standard plugs are made of a special wear-resisting steel which have shown no deterioration whatever in long use.



Cam rollers in "astern" position



Cam rollers in "ahead" position

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EACH cylinder has a separate pump which feeds the fuel to a distributor formed out of a block of solid-forged steel, from which are led the pipes to each pair of sprayers. The pumps are fastened to the camshaft brackets and are operated from the camshaft by short sharp cams, very similar to those ordinarily used for air-injection valves. They work for ahead and astern running without change of setting. The control of the amount of fuel sprayed into the cylinder on each stroke is effected by means of eccentrics mounted on a control-shaft extending below the camshaft, and which permit the return to the intake of a certain definite amount of the fuel that is being pumped forward on the supply-stroke.

the proper convenience for adjustment of the twin sprays.

UNDER all normal operating conditions there does not arise need for such adjustment, the extreme simplicity of the design of the sprays presenting no parts to get out of order. Dirt in the fuel is practically the only possible cause of derangement.

FOR the location of the camshaft the top of the engine was chosen, this being conveniently situated for inspection from the upper platform. The camshaft bearings are supported in brackets bolted to the tank-top between the cylinder heads. The same brackets support also the bearings of the fulcrum shaft for the valve rockers.

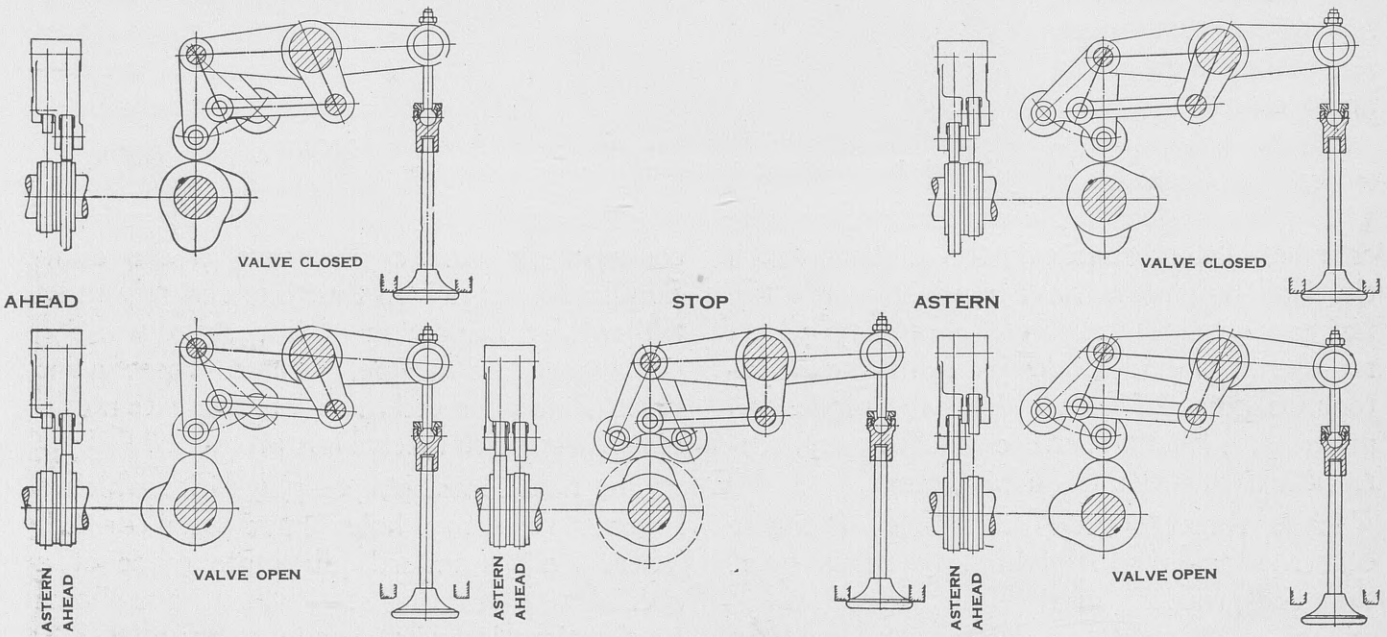

Diagram of reversing mechanism of Falk oil-engine

WITH the airless-injection system and spraying devices used in this engine, the balance of advantages lies unquestionably with the method adopted of mounting the separate fuel pumps individually on each cylinder line near the valve gear. Grouping of the fuel pumps is not suited to this design of engine.

IN the first place, with airless-injection it is very desirable not to have a great length of line between the pump delivery and the sprayer. Secondly, for equality of timing, it is a considerable benefit to have equal lengths of pressure lines between the individual pumps and the sprayers they feed. Thirdly, the fuel distributor should be located close to the pair of spray-valves it serves, in order to provide

A HERRINGBONE gear drive was finally decided upon for the camshaft, because although this type of gear is very expensive it is also very exact and much less subject to wear than any other. The camshaft gear drive in the Falk engine takes not only the load of the operation of the valve cams, but also has to withstand the sharp ramming strokes of the fuel pumps which work at very high pressure. The pinions and gears are steel castings, and after considerable use during the engine trials have disclosed no sign whatever of wear. The drive is taken off the crank-shaft between the last main bearing and the thrust bearing. At the back of the engine an auxiliary gear drive is fitted for the indicator mechanism.

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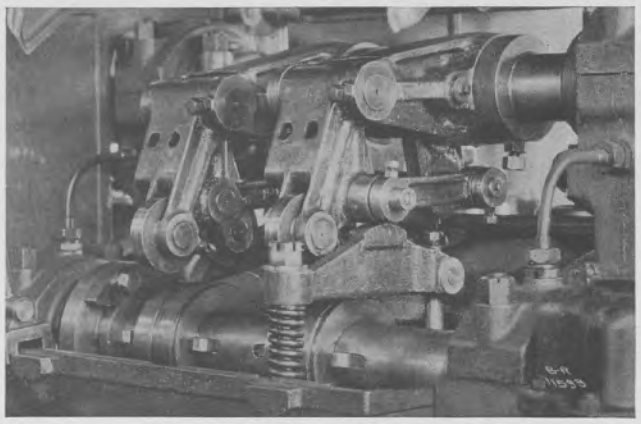
A GEAR train of this sort retains an unexcelled accuracy of camshaft drive for both ahead and astern running, which in combination with the quietness attained by the herringbone gears, is far superior to any arrangement that comprises plain spur-gears. As will be explained later in this article, the gearing is provided with positive lubrication, the flow of which is indicated through a sight feed cup on top of the gear-housing.

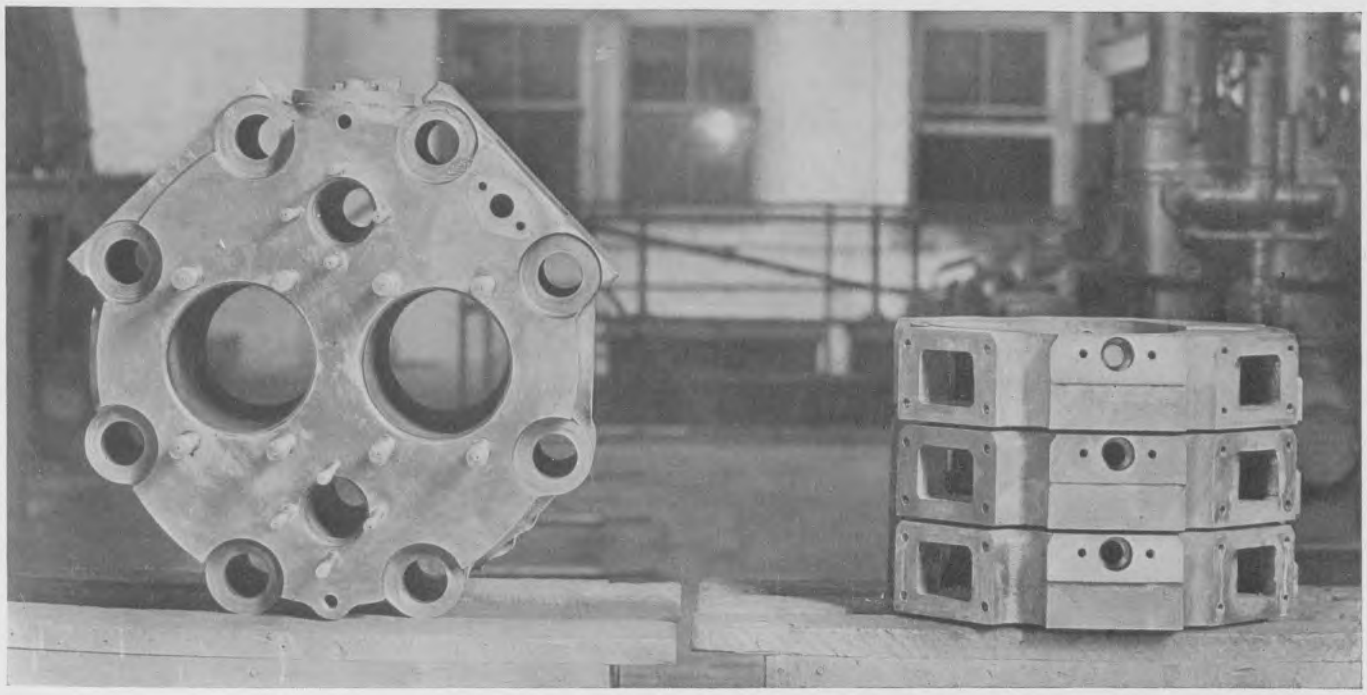


Showing camel hump which gives against a spring resistance when the pressure is high in the cylinder during maneuvering

FOR the reversing mechanism of the inlet and exhaust valves a system has been adopted which is very simple and straight-forward and can be set much more positively than many of the reversing systems now in use. Fundamentally, it is an old and well tried system, but the detail has been worked out in a new way. The desire of the Falk engineers was to obtain a reversing mechanism which could be operated by a mere turn of the fulcrum shaft. They considered this a considerable advantage in keeping with the simplicity and symmetry of the rest of the valve gear.

WHEN the reversing mechanism can be so devised that there is only a single motion to be performed, which is actually the case with the Falk system of reversing, there is a directness and positiveness of control and operation which makes it essentially as easy to reverse four engines as to reverse only one when the mechanism of the four sets is linked up to a single control.

IN THIS engine only the timing of the inlet and exhaust valves has to be altered when the engines are reversed. The solution adopted was to mount on each valve-rocker two separate rollers, each engaging with an ahead and astern cam respectively as required. In this way no mechanism is added to the camshaft or to the camshaft drive which in any way allows lost motion.



On the left a cylinder head; on the right cast-steel heat shields, one of which goes between each cylinder and cylinder-head

THE valve rockers are plain double-ended levers. On the outer end is pinned a hanging triangle, in the lower corners of which are the two rollers, in two different planes. Right next to each valve rocker a bell-crank is

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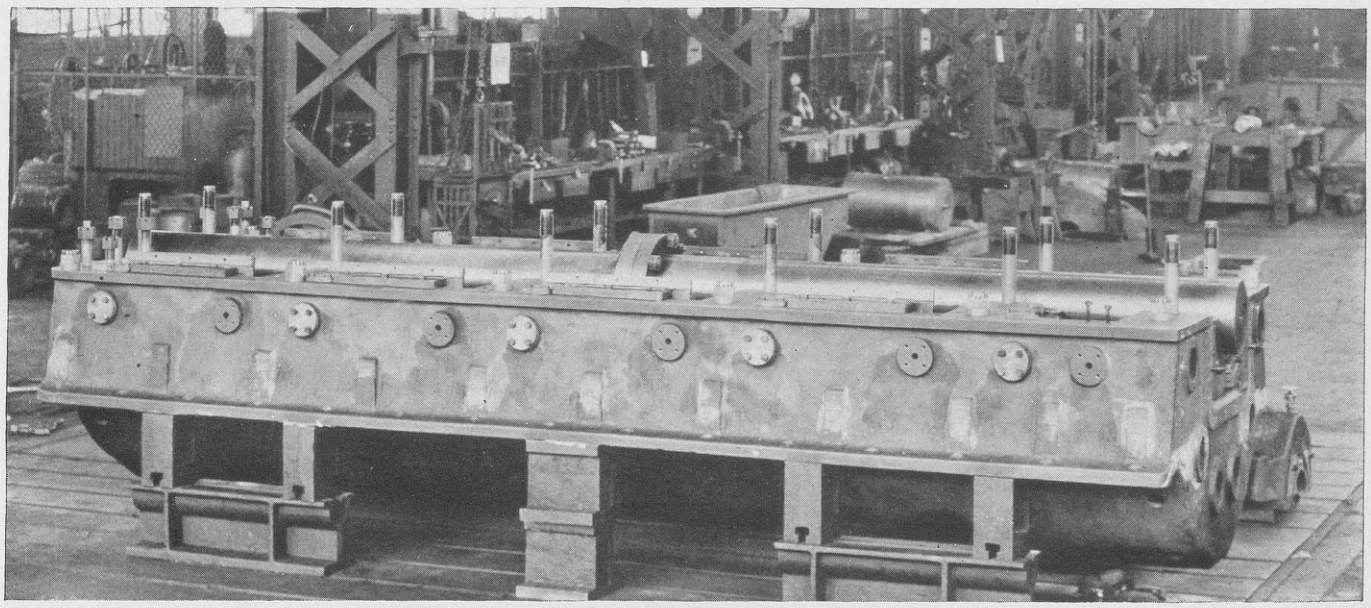
mounted on the fulcrum-shaft and a short link connects this with the hanging triangle. It can be seen plainly on looking at the diagram of this reversing mechanism that a turn of the fulcrum-shaft in one direction or other will either pull or push one of the rollers into contact with its cam. That is all there is to the reversing mechanism!

BETWEEN the centers of the two rollers there is a sufficiently wide angle to permit both rollers being simultaneously out of contact with the cams, thus providing a neutral position. It is in this neutral position that the exhaust valves are arranged to open, in order to provide against the occurrence of excess pressures during the period of valve shifting, because, of course, when the rockers are inoperative and the valves therefore not being opened, the normal exhaust stroke becomes a compression stroke. The simple mechanism for relieving the cylinder pressures when the reversing mechanism is in neutral consists of a camel-hump, across which a roller on the side of the hanging-triangle is drawn each time it passes from ahead to astern or vice versa.

TO TAKE care of the condition where the pressure existing in the cylinder is higher than that against which the exhaust-valve is designed to open, the camel-hump is designed to give way against a spring pressure. Therefore, the exhaust-valve is never forced to open against an excess of pressure, but will open only when the gas pressure has fallen sufficiently to permit the spring under the camel-hump to overcome the gas pressure. Whenever the regular cycle comes into operation again through the valves being set for ahead or astern running, the camel-hump is inoperative.

ALL the mechanism for the starting valves is assembled in a box at the free end of the camshaft. The starting valves in the cylinder heads are really only check valves. In the starting-valve boxes there are ahead and astern cams for the starting valve belonging to each cylinder, and the starting-air valves are out of contact with all the cams except when the starting air is turned on. The admission of the starting air to the valve-box sets the starting valves ready for operation, and each valve is in turn opened by the appropriate cam and immediately closed when the cam is passed over it. The selection of the ahead or astern cams is made by the turning of the fulcrum shaft. This provides a very compact and easily inspected arrangement of starting mechanism.

THE box is a bronze casting, and the valves are made of the same steel-like non-rusting alloy as the starting check valves and relief valves in the cylinder head. From the valve chest four heavy copper pipes conduct the starting air to the check valves in the cylinders. In actual operation 300 lbs. is the



Method of lining-up crankshaft bearings of Falk oil-engines

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maximum starting pressure used, but with sixteen cylinders the group of engines can start on 115 lbs. and with eight cylinders can be set under way with 150 lbs. The storage tanks are filled at 350 lbs. pressure and have been built to withstand a test pressure of 600 lbs.

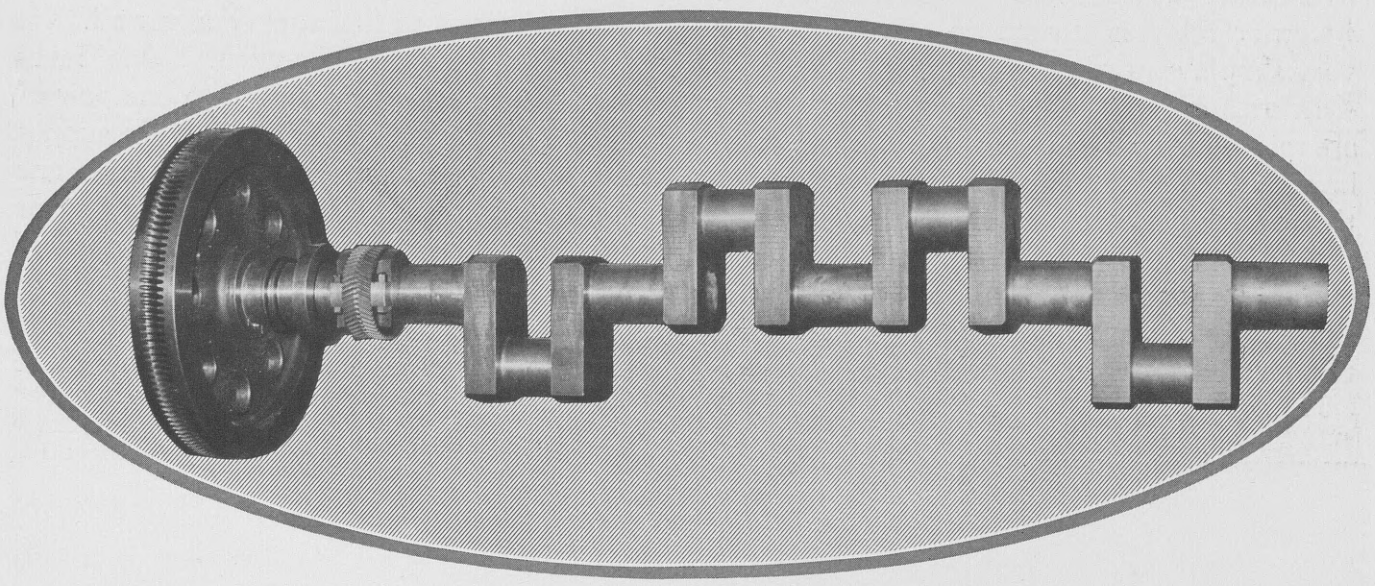
OVER the whole valve gear on top of the engine there are wide aluminum covers, which encase the mechanism almost completely, leaving only space for the valve ends of the valve rockers. These covers are hinged over the top of the engine and can be opened from the front to give complete access to every part.

ALL the valve mechanism is oiled by auxiliary feeds from the main forced lubricating system of the engine. The oil is supplied at 7 lbs. pressure to a header on the baseplate from which, as already described, it is fed to the main bearing covers and thence to the connecting-rod ends. At the gear end of the engine a separate connection is made for the oil feed of the camshaft gears and their bearings. Another separate connection leads up to the fulcrum shaft, each section of which is drilled through its full length. The oil passes through the fulcrum shaft to feed all fulcrum and camshaft bearings and all valve levers, triangles, rollers, links and oil pumps. On the highest point of the camshaft-gear cover there are fitted two sight-feeds for the lubrication of the camshaft-gear teeth. So long as the oil is seen running through the sight feeds it is an indication that the entire lubrication of journals and pins through the engine is being automatically carried out.

INTAKE and exhaust manifolds have been placed on the cast steel brackets which support the upper platform at the back of the engines. The exhaust manifold, as well as the exhaust elbows are water cooled, the cooling water flowing into them from the crown jackets. The cooling water enters the engine through the tank and passes around the cylinders up to the jackets of the heat-shields and cylinder heads. There are valves on top of the cylinders to control the flow of water in each cylinder line.

PROVISION is made on the engine for an indicator-gear drive of quite substantial design. It is the opinion of the Falk engineers that where convenient mechanism is provided for taking indicator diagrams there will be no negligence on the part of the operators in making a daily test of the conditions in each cylinder. The indicator shaft is driven off one of the idlers of the camshaft-gear drive, and the cranks are led upward from this to a convenient location above the platform. The indicator shaft has ring bearings, and use is made of it to drive the McCord mechanical lubricators for the piston oiling.

CONTROL of the four engines is centralized in the middle of the platform and interconnected as if the whole group formed a single engine set. The control consists of four



Fly-wheel and crankshaft of 550 b.h.p. Falk oil-engine

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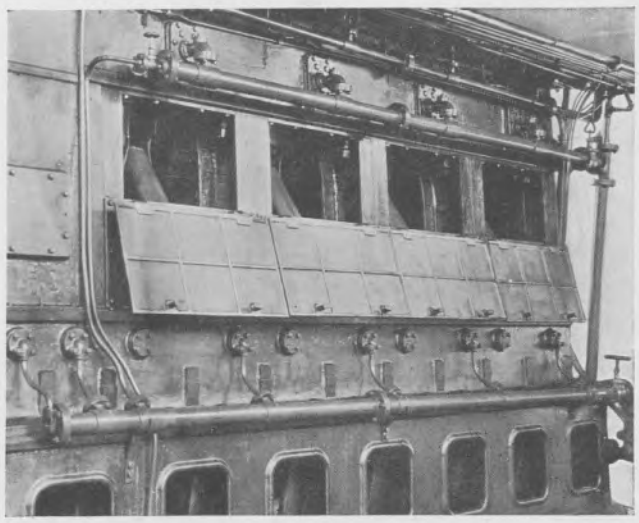


Crankcase inspection doors open

levers, and the only instruments used are a speed indicator, two starting-air gauges, one voltmeter to indicate whether the switch for the reversing engine is cut in, and one gauge to indicate whether the oil pressure for the governor relay is turned on. This makes a very simple control station.

In the control box the two middle levers are raised for convenience above the two outer levers. One of the two upper levers controls the reversing motor, while the other regulates the fuel spray on all four engines simultaneously. The two lower, or outer, levers control the supply of starting air to the two port and two starboard engines respectively. The operations of reversing, starting and fuel regulation are interlocked to prevent any mistakes being made.

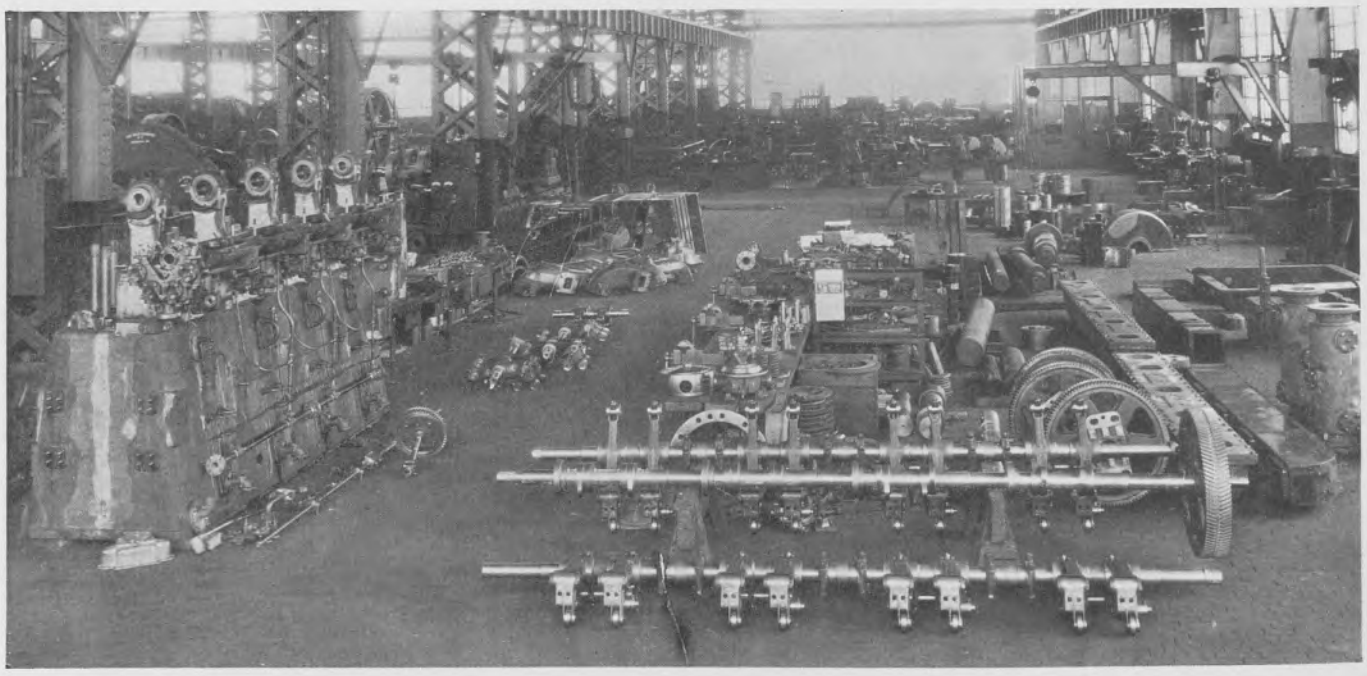
Described in a little more detail, the connection between these various control levers and the corresponding mechanism of the engines will become plainer.

(1) Reversing Lever. Movement of this lever sets in motion an electric motor which, through a worm reduction-gear, operates a heavy screw and nut device connected by rods and levers to the two lay shafts, which select and regulate the position of the fulcrum shaft on the two port and starboard engines respectively.

(2) Fuel-Regulating Lever. By direct motion from this lever to two layshafts under the platform, which in turn are connected to the fuel-pump control shaft of both pairs of engines respectively, the position of the eccentrics regulating the fuel supply is varied.

(3–4) Starting-Air Levers. One lever controls the starting-air supply to one pair of engines and the other lever controls the supply to the second pair. Each lever actuates one main cut-out valve which admits starting air to the starting-air boxes of one pair of engines.

This gives a very simplified control. Such instruments as are fitted on the board are



Component parts of one 550 b.h.p. Falk oil engine ready for assembly. Note tank part of frame on the left

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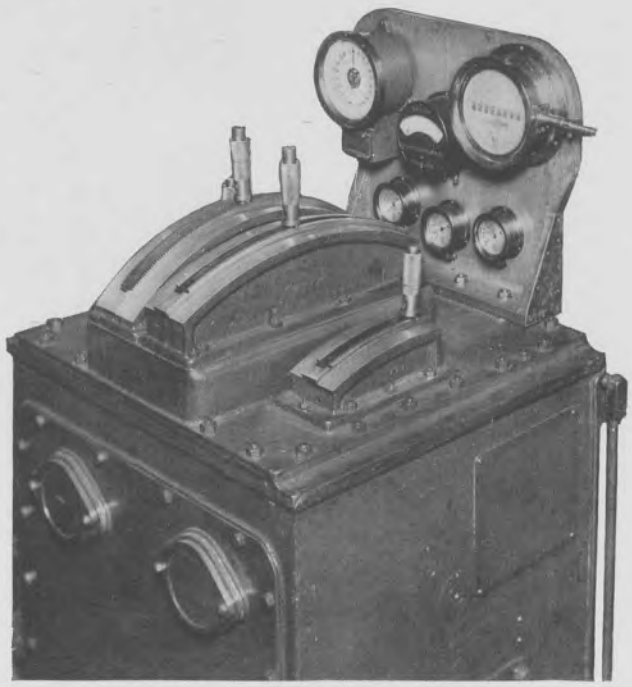
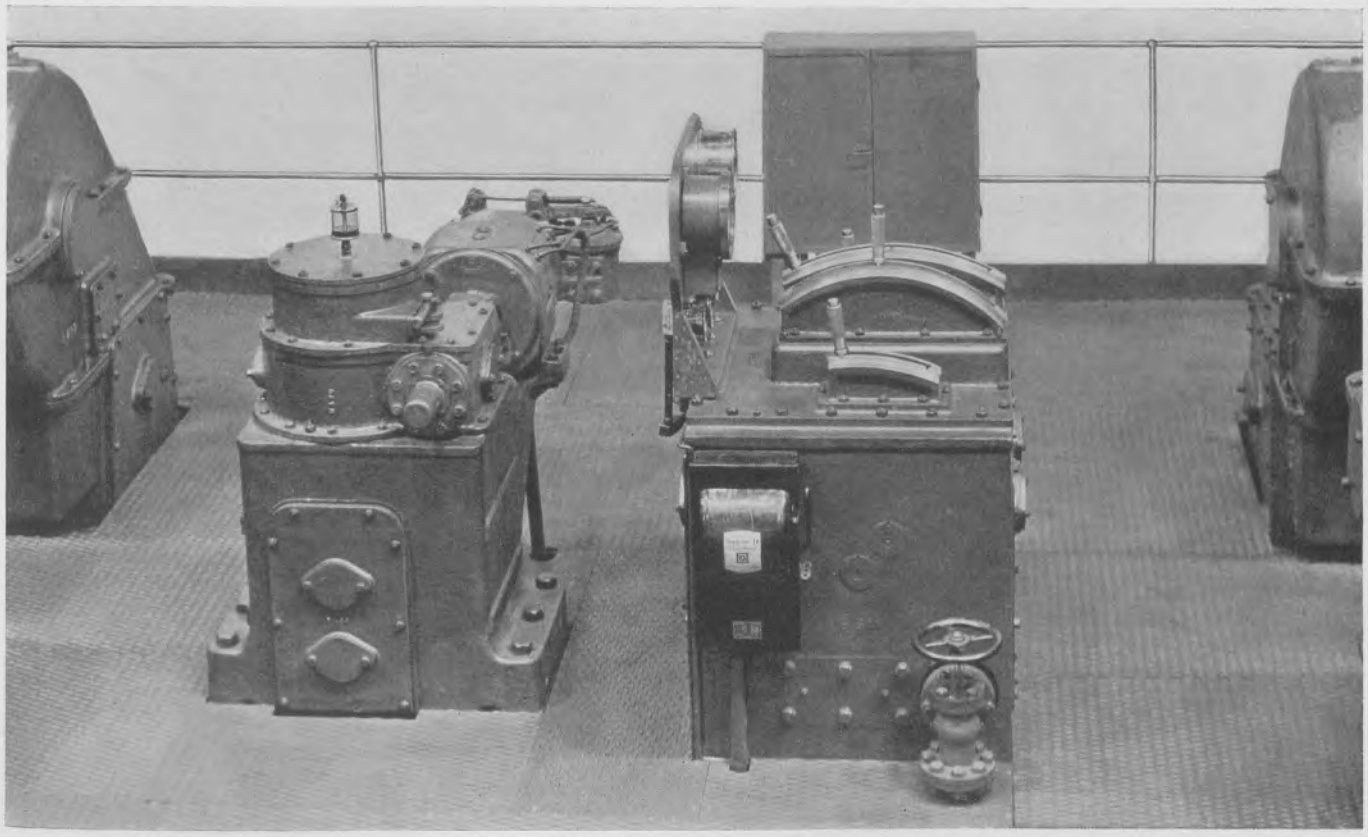
utilized only during maneuvering, with the exception of the speed indicator which is a convenience appreciated by the engineer at all times. There are, however, no injection-air gauges nor drains nor throttles to be watched under normal operation as required on an air-injection engine. Moreover, the need for watching the injection-air system during maneuvering is a task of which the operator of the Falk engine is relieved, with consequently greater freedom for watching the signals from the bridge and carrying out orders promptly.

THERE is an advantage also in the maneuvering of the Falk engine arising from the fact that it is immaterial whether the fuel injection is cut-out during starting-air admission, because detonations during starting do not occur. The fuel measurement depends upon one pump stroke per charge, the beginning and end of which is fixed by the notch in which the control lever is set, the determined amount of fuel then being delivered at invariably the same time under invariably the same conditions into the combustion space. This is in contrast with the variations that can occur in the ordinary Diesel engine, due to the independence of the injection timing and the pump feed, and due also to such influences as friction of moving parts, varying viscosity of the fuel, etc.



The control handles for four engines

IN the gradual change of engine-room traditions that follows in the wake of the oil-engine



Reversing and maneuvering of all four engines are controlled by electricity through the medium of the four hand-levers illustrated above. The motor-driven reversing machine can be seen to the left

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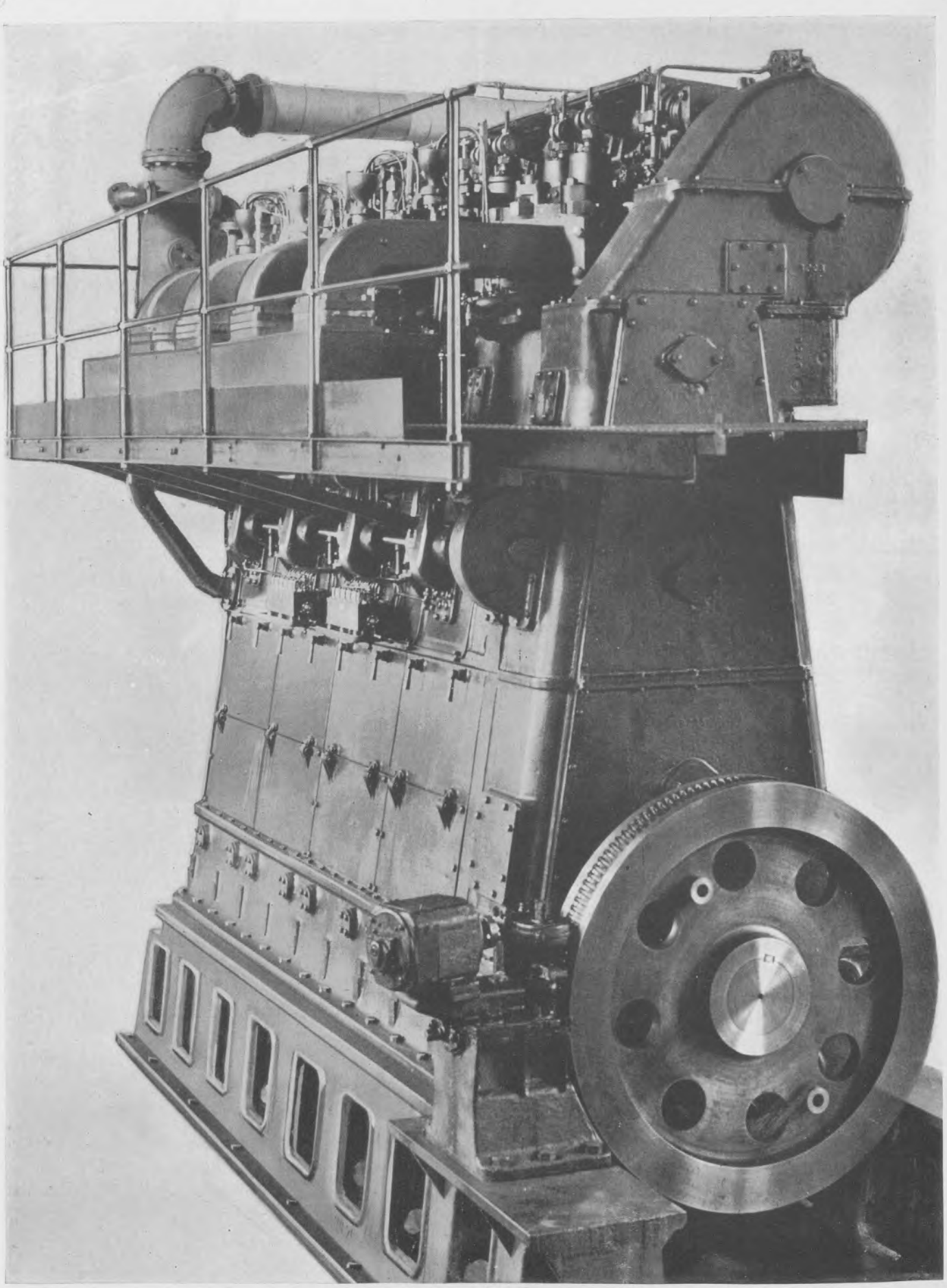

Falk oil engine seen from the coupling-end, showing clearly the barring motor. In this view of the back of the engine the shaft for driving the indicators is seen below the grating, also the McCord force-feed lubricators

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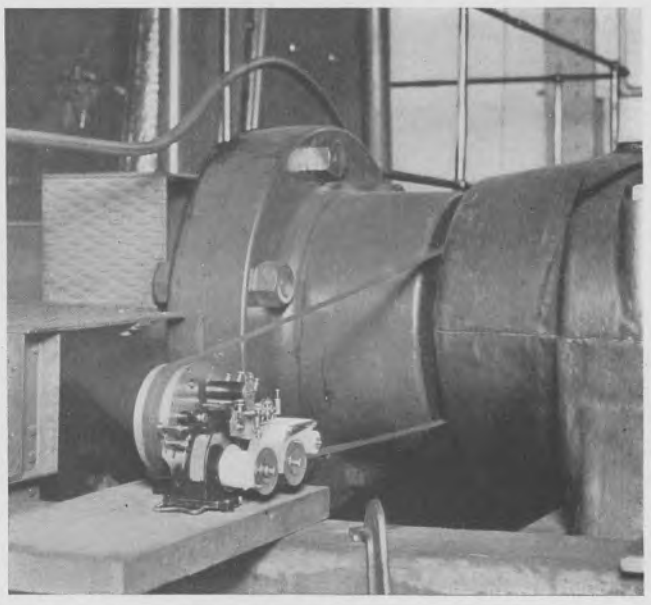
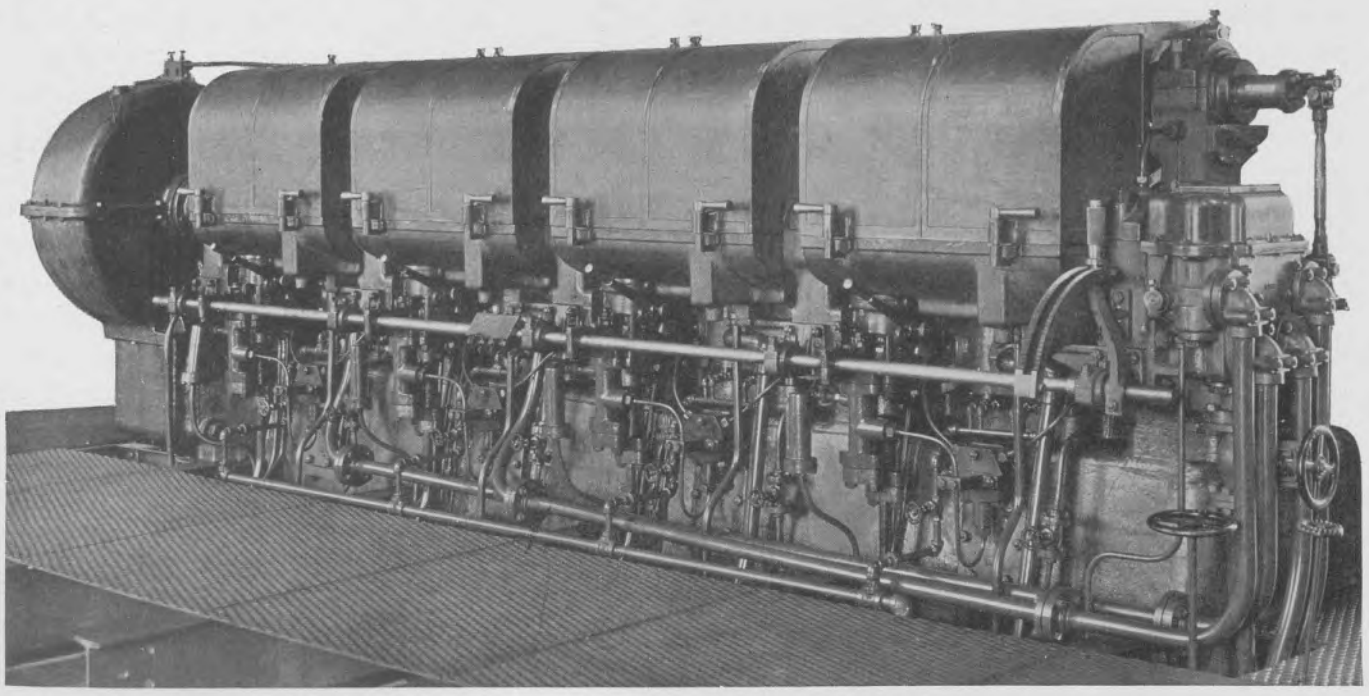
there is little doubt that the location of the engineer's platform will ultimately be on the upper grating, as it has been arranged in the Falk group.

THERE is no longer any reason for the engineer to stand on the plates below. The practically universal adoption of the enclosed crankcase for the marine oil-engine has shut off the engineer's view of the rods and cranks which he was accustomed to keep his eye on when reversing or running dead-slow or turning his engine over to warm her up. On a motor-ship the engineer has his thought chiefly upon the camshaft and valve-gear when reversing, and that mechanism is always above the grating. Logically, he should have all the valve-gear and reversing mechanism under view, and in course of time he will surely demand that the controls be located in such a way as to satisfy that condition.

A QUESTION might have arisen about the maintenance of the setting of the fuel sprays in the Falk engine during any periods of running. During the trials it has been found that no trouble has arisen under this head with the four separate engine units of the group. In a few instances only was it found that the power of a cylinder had varied, and the discovery was made in each of those cases that the change was due to dirt obstructing the nozzle opening. With the provision of convenient indicator gear on this engine the equal operation of the cylinders is easy to check. A more ready, but not so accurate, indication can be obtained from the thermometers on the exhaust elbows, the heat passing out through the exhaust valves giving a very fair indication of the load in the cylinder. It is an easy matter to correct an overload in any cylinder line by a slight turn of the adjusting screw on the eccentric control of the pump.



Using the torsiograph on the propeller-shaft aft of the four engines



Showing oil-splash guards over camshaft mechanism, also individual fuel-pumps for each cylinder

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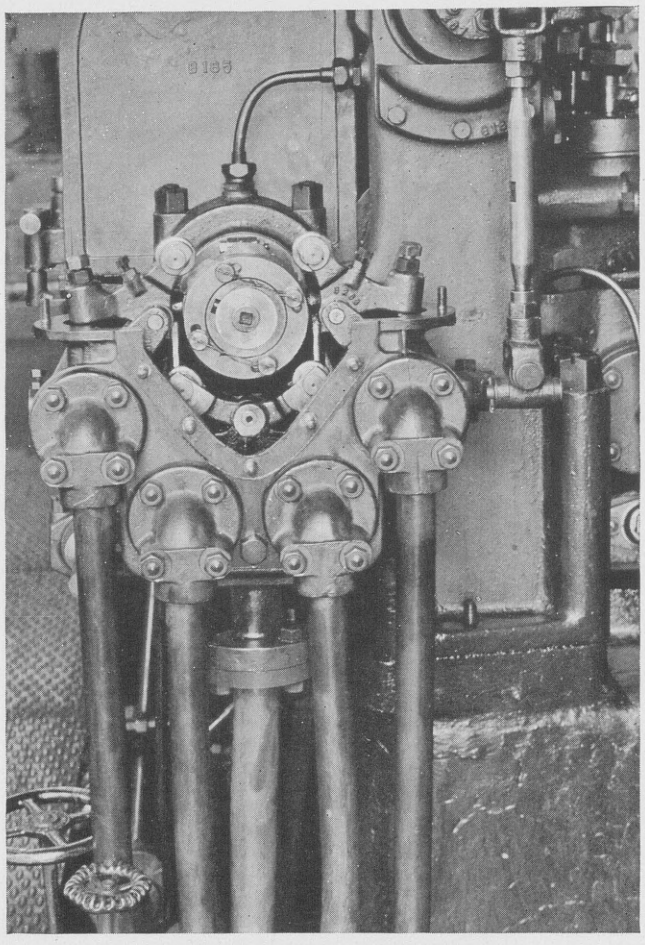
In operation and control therefore, it is clear, the Falk engine realizes unusual advantages from the simplification of the details of the mechanism. That nothing has been sacrificed thereby to efficiency is proved by the test results published on a later page.

The Falk-Bibby Couplings

In the connection between engines and reduction-gear there is evidence of the same profound thought and thorough care which are so manifest in the engine itself. One of the leading ideas in the design of the Falk marine engine was to have an articulation between unit engines and gear pinions, so that there was to be no connection between engine bedplates and gear case. Obviously such a design has great inherent advantages from the standpoint of manufacturing and of operating. It permits the independent production and testing of engines and gears, and the standardization of a number of important parts consequently is greatly simplified.



Showing starting-air distributing mechanism, with valve-casing cover removed

Since it is necessary to take into consideration the elastic deformations of the hull, which are continually changing, a coupling permitting of a certain degree of misalignment has been considered essential. The question of the design of such a coupling has for many years been foremost in the minds of The Falk Corporation's engineers, its importance becoming paramount with the perfection of the marine turbine gears.

The couplings first used on the marine engine were of a well proven heavy-duty type, shown on the engine drawings. The elastic and movable elements were leather rings. They worked satisfactorily enough, but were not considered the final solution, for the reason that the modulus of elasticity of the leather changes over a wide range with increasing time of use. In order to understand the importance of this change, it will be necessary to explain the elastic conditions of the installation.

Any rotating system consisting of a combination of masses and shafting can, under certain well-defined conditions, set up periodic torsional oscillations, which may become extremely violent and may result in destruction of some of the moving parts. If, for instance, the case of a steam turbine be considered, driving a direct-current generator through a reduction gear and flexible coupling, the gears being of a reasonably high degree of perfection and the generator running under an even and steady load, then the torque in the shafts and rotors and the bending deflections in the spiders and teeth will remain constant at all speeds, and no oscillations will be set up even if one part of the system is running at a speed which coincides with one of its harmonic speeds. But if this same turbine and same gear be placed on board of a ship and connected to a propeller, the connecting shaft being very short and having the same elastic characteristics as the flexible coupling, then extremely dangerous oscillations may be excited by the propeller. The torque at the propeller is not constant; it varies during one revolution several times according to the number of propeller blades. If the periodicity of this fluctuation coincides with the harmonic period of the low speed system, which consists of low speed gear, shaft and propeller, then a dangerous torsional oscillation is excited.

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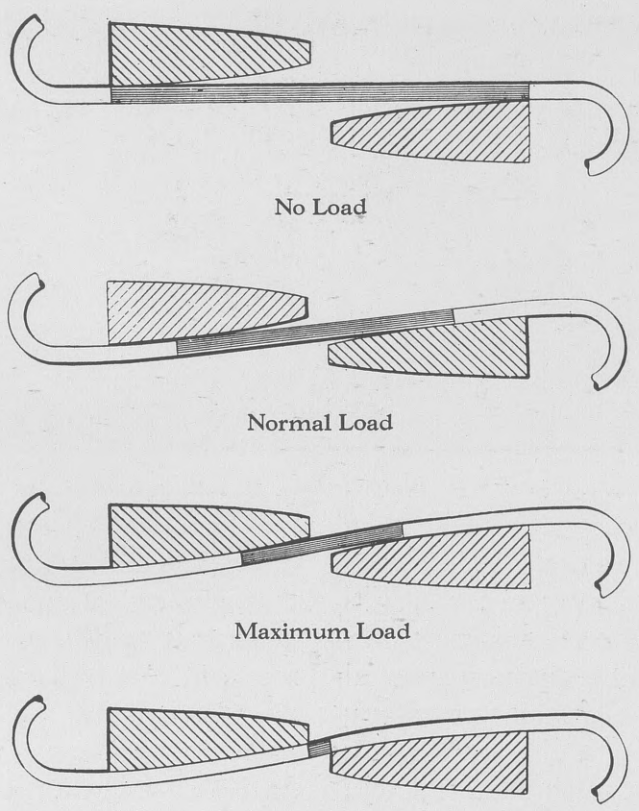
THE fluctuations impressed by the propeller are not very strong compared with the impulses impressed upon the crankshaft of an oil engine. Heavy flywheels afford no relief, and on the contrary may become a great danger in case the engine has to run in or near a torsional critical speed. In fact, fifteen years ago a great deal of trouble was experienced from this cause in the powerful Diesel-engined sidewheel tugs which were put into service on the Volga in Russia.

A FLEXIBLE coupling regarded from the viewpoint of torque conditions is equivalent to a length of shaft. It becomes apparent now that a coupling, the flexibility of which depends upon a material having a variable modulus of elasticity, is undesirable, because with the variation of the modulus vary also the critical speeds of the system. In the present case these were not of importance, because the symmetrical arrangement of the masses and elastic lengths with reference to the center of the pinion brought in the tremendous advantage that the center of the pinion and, together with it, the whole length of the teeth are in a node of the oscillation, so that they could have no influence on the teeth, which thus rotate just as if no oscillation at all were occurring. The drawing of the form of the oscillation of the high speed part at the first critical shows this plainly. The higher criticals occur at speeds which are way above the highest operating speed of the engine in the ship. Similar conditions exist with regard to all important sub-criticals. Such fortunate conditions do not exist in single-ended drives, where the engines are set on one side of the pinions only.



Action of Spring in Bibby Coupling under Variations of Load

IN ORDER to find out the conditions prevailing on geared ship drives, The Falk Corporation had an investigation made on a number of geared turbine-driven ships, which showed that critical conditions existed in all cases, but that they occurred only at speeds outside of the ranges used in regular operation, and in all cases sufficiently below the running speed. For these investigations a very sensitive torsiograph was used which recorded the oscillations in the shafting with great accuracy.

THE natural frequency of the system—low speed-gear, connecting shaft and generator armature—was found to be very low, lower than could be expected on a standard ship. The first natural torsional frequency of the crankshaft and flywheel of a unit engine was way above the highest running speed, but with an elastic coupling interposed between crankshaft and pinion it could be brought down at will. It was thought desirable to have only one critical in the system, which had of course to coincide with that of the low speed part. For these conditions a set of steel springs were calculated which, when fitted in the place of the original elastic members, gave exactly the predetermined results.

IT IS obvious from these explanations that the couplings are of the same importance as the engines and the gears. What was expected of such a coupling was this: It should have a flexibility which can be exactly predetermined and which must be permanent; it should be able to transmit the starting torque with perfect ease and to resist without injury the shocks which may occur when the propeller strikes a solid body; its

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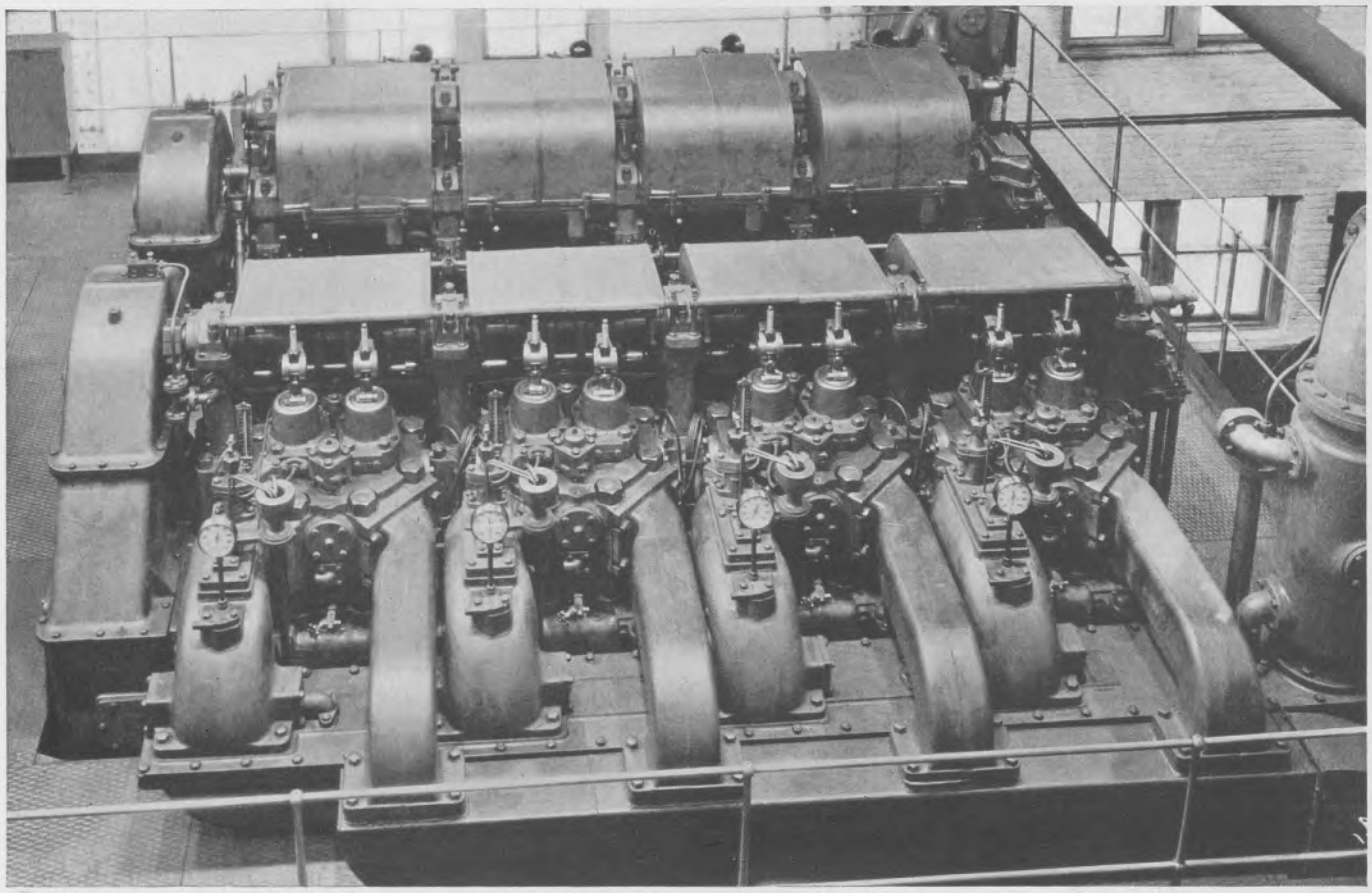

Showing cylinder heads, inlet and exhaust valves, air intake manifold and exhaust-header

design should be such that the elastic conditions can be easily changed, even in case it has been already installed in the ship; it must permit axial displacements of the shafts and radial and angular misalignments of their centerlines; it must be easily assembled and disconnected; and all parts must be of such material and design that permanent and uninterrupted service can be maintained. It should be of a short axial length only. The Falk Corporation's engineers decided that the coupling which incorporated all of these properties and functions, with other desirable advantages, was the one designed by James Bibby, and for which The Falk Corporation acquired the sole rights for the United States of America.

This coupling consists essentially of two members keyed to the respective shaft ends, these members carrying oppositely arranged peculiarly shaped teeth, and a serpent-like flat spring inserted in the gaps between the teeth. Both teeth and spring are covered by a retainer ring closed at the sides. By varying the cross-sectional dimensions of the spring and the length between the abutments any desired flexibility may be obtained, so that the torsional conditions of the system can be controlled at will. Also, since the springs are made in certain lengths apiece, by fitting an oversize coupling, it is very simple by adding or taking out some lengths to vary the total flexibility at will. The springs are packed in grease and fit easily in the slots. They permit of a considerable degree of misalignment and axial movement. Since the load is distributed over a great number of leaves wear does not occur. By shifting the cover ring aside the springs are bared. They can be taken out in a few minutes with a screw driver, so that the disconnection of a unit engine from the gear is a very simple matter.

One of the most remarkable features of this coupling is its behavior at loads surpassing the normal one by a certain amount. By giving the teeth an appropriate curvature a spring characteristic can be obtained which at normal loads gives a proportional variation between deflections and loads, but if the load increases beyond the range of direct proportions the spring reaction increases tremendously at very

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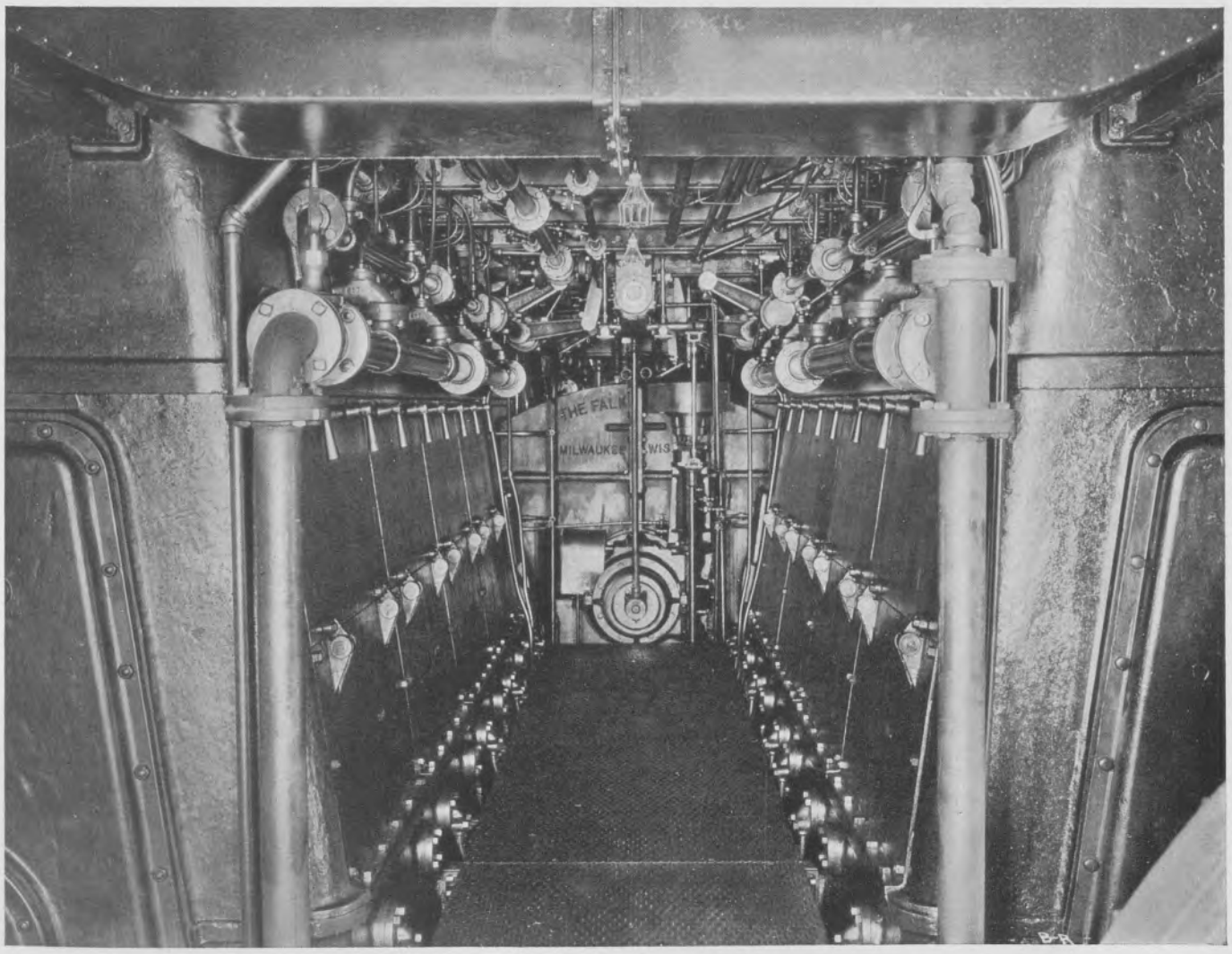
small deflections, until finally the spring leaf abuts against opposite teeth corners, thus producing plain shearing reaction. Such a characteristic enables an engine to pass easily through a range of torsional critical oscillations which to quite a degree will be broken, sometimes entirely suppressed.

After the experimental work on the engine couplings had been successfully concluded and the result of the calculations found to be correct by the tests, Falk-Bibby couplings were fitted.

For testing in the Falk shops the four engines with the reduction-gear have been erected and coupled to a shaft driving an Allis-Chalmers generator rated 1,500 K. W. at 90 r. p. m. The port forward engine has been coupled to a water brake capable of absorbing 600 b. h. p. at 200 r. p. m. With the aid of both generator and water brake a load of 3,000 b. h. p. can thus be carried on the group for several hours. The brake was designed and built by The Falk Corporation. Over the range of power obtainable in this installation it has been found that the calculations originally made showing a sufficiently steady torque to permit a fly wheel to be dispensed with, were entirely correct. It has been found also that the governor operation is excellent, the voltage being remarkably steady even under frequent load changes of considerable magnitude. The engine serving at present mostly as a generator drive, an exact regulation has been provided by means of an oil relay controlled by a governor.

In the equipment provided for the group in the test house are starting-air receivers, lubricating-oil pumps and fuel-service pumps. The starting-air receivers, two in number, have a capacity of 400 c.f. each, and were built under the supervision of Lloyd's surveyors. The lubricating-oil pumps, which are of the



View between two engines on the engine-room floor level, showing reduction-gear in background

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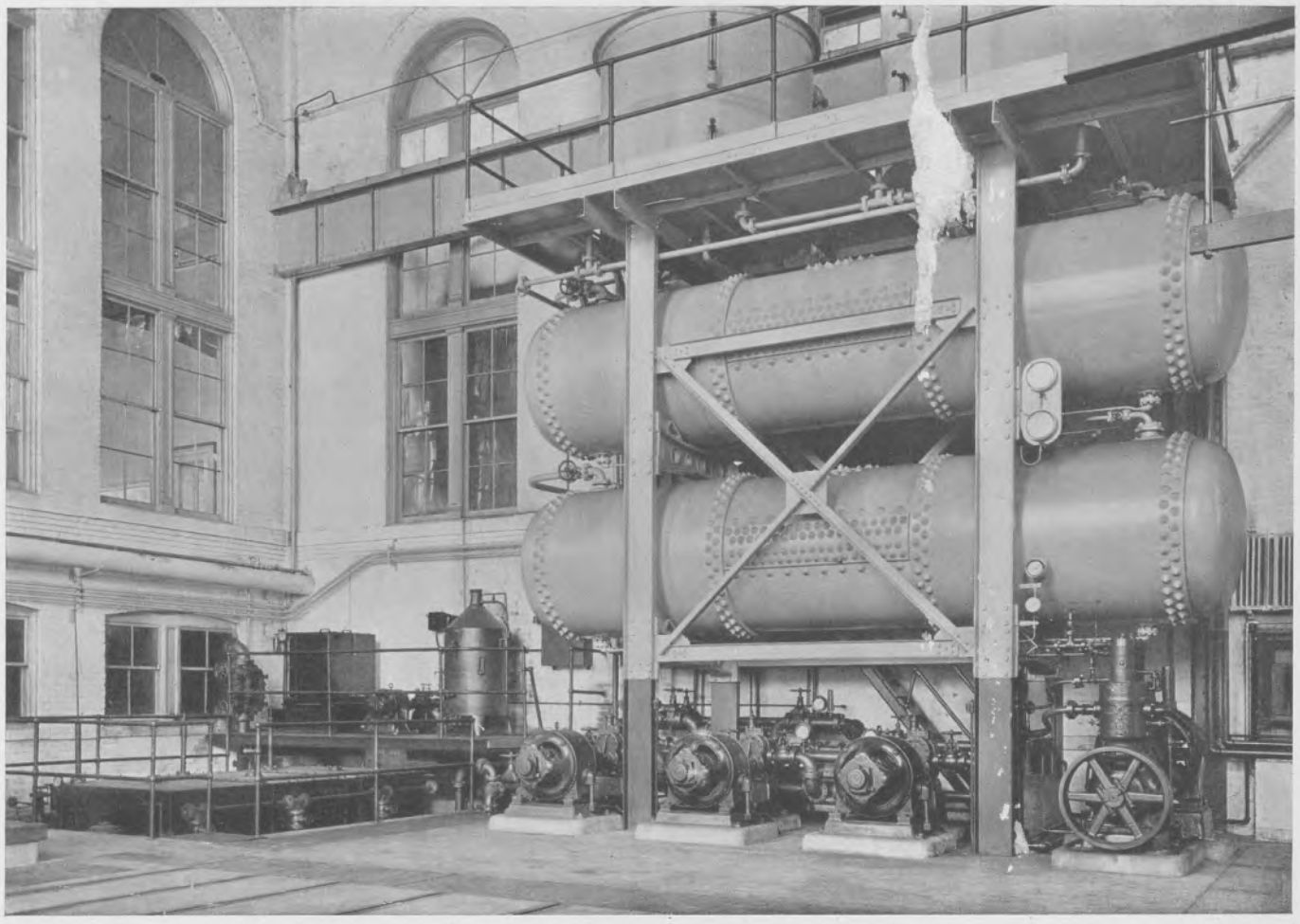
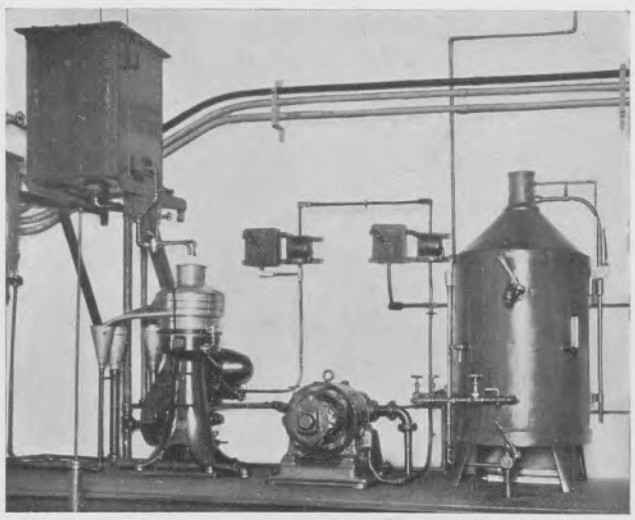


The engine-room auxiliary equipment, incorporating pumps, auxiliary air-compressor, maneuvering-air tanks, and Richardson-Phenix lubricating-oil reclaimer. A De Laval oil-separator has been added as a standard equipment and is shown in the illustration below

gear type, are driven by 8 h. p. motors. One pump is sufficient for engine and gear, two others being held in reserve. A De Laval purifier is coupled into line and has been found to effect considerable economy.

An auxiliary compressor of relatively small size is included in the equipment. Its sole function being to replenish the starting-air receivers, which are filled only at 300 lbs. per sq. in., it does not require to have more than two stages of compression. Because of the large capacity of the air-receivers, each of which holds a supply permitting the Falk unit to be started 25 or 30 times, the compressor itself does not need to be big. It can refill a discharged air-receiver in about 40 minutes, which is ample for the conditions that will arise in actual operation.



The reclaimer and De Laval oil-separator forming part of the standard engine-room equipment

All the auxiliary equipment that goes to the service of a complete four-engine geared unit has been grouped in one corner of the power house at the Falk plant. Its general assembly is well shown in the illustration on this page, the fuel-settling tanks, however, being partly cut off at the top of the picture. In this way a comprehensive idea is

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given of the space occupied by a complete installation, including the auxiliaries as well as the main engines. No account, of course, has been taken of auxiliary equipment for the ship's service such as bilge-pumps, ballast-pumps, sanitary pumps, electric generators, etc., because their selection is dictated not by engine requirements but by ship requirements, and when they have been decided upon for any particular vessel they will remain unaffected by the shipowner's choice of main propelling machinery.

Main interest centers, of course, in the geared group of four-cylinder engines, because that is the first example built of the Falk marine oil-engine system, which can also be variously carried out with twin engine sets or with six cylinder units.

Weight and Dimensions of 2,200 B.H.P. Falk Unit

Complete Installation Figures Out at 293 lbs. per Shaft Horsepower

IT WILL have been surmised from the foregoing description that the total weight of the Falk marine oil-engine unit is kept down to a relatively low figure by the advantages of its design. By careful measurement during the course of the erecting work in the shops, the total weight of the four-engines, with flywheels, couplings, reduction gear, platforms, control gear and all piping on the engine was ascertained to be 645,000 lbs. which is 293 lbs. per brake (shaft) horsepower.

FOR the same reasons that affect the weight of the engine, the overall dimensions are also relatively compact. The principal dimensions of the Falk unit of 2,200 b.h.p., as erected, are

Length overall..... 45 ft. 2½ ins.
Width overall..... 16 ft. 2 ins.
Both dimensions measured between ends of bedplates.
Height from center of crankshaft to top of valve gear..... 12 ft. 10 ins.
Clearance space above center of crankshaft to draw pistons.... 16 ft. 1 in.

WHEN referred to indicated horsepower, the weight and dimensions of this marine unit are made to appear less favorably, because of its high mechanical efficiency. Indicated horsepower, is of course, misleading as a basis for comparing oil engines, and the growing tendency to use it in measuring the power of oil-engine sets for ships is not to be commended.

IN order to prevent a misconception of the weight and size of the Falk unit, it will be useful to direct attention to the fact that though the shaft horsepower, which is the only power that is of service to the shipowner, is 2,200, the indicated horsepower is no more than about 2,700 at the coupling flange of the low-speed gear. Yet this must be compared with, say, 2,900 i.h.p. in an average four-cycle set or, say, 3,000 i.h.p. in an average two-cycle marine Diesel engine, both of which types have lower mechanical efficiencies. Indicated horsepower is much more convenient for the engineer to measure than shaft horsepower, but it should be ignored by the shipowner.

IT is only on the basis of shaft horsepower that the weight and dimensions of the Falk unit should be considered, and on that basis they are very favorable. If only one engine is to be coupled to one pinion, in which case six cylinder units would have to be installed, the length of the complete engine can be cut down very considerably, so much in fact, that for large outputs only very few systems in existence can compete with the Falk Engine in this respect. The blueprints bound in the back of this book show the overall dimensions.

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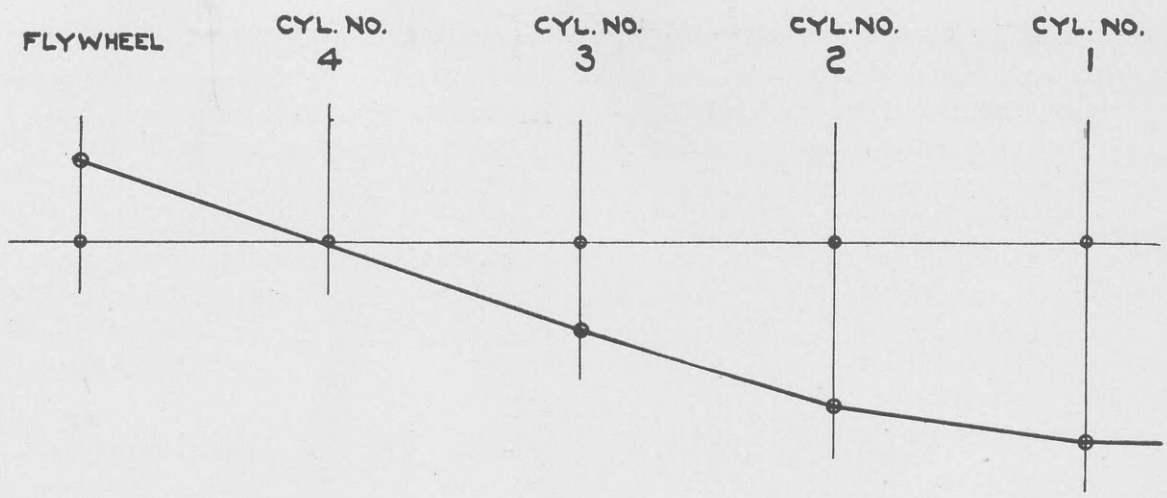
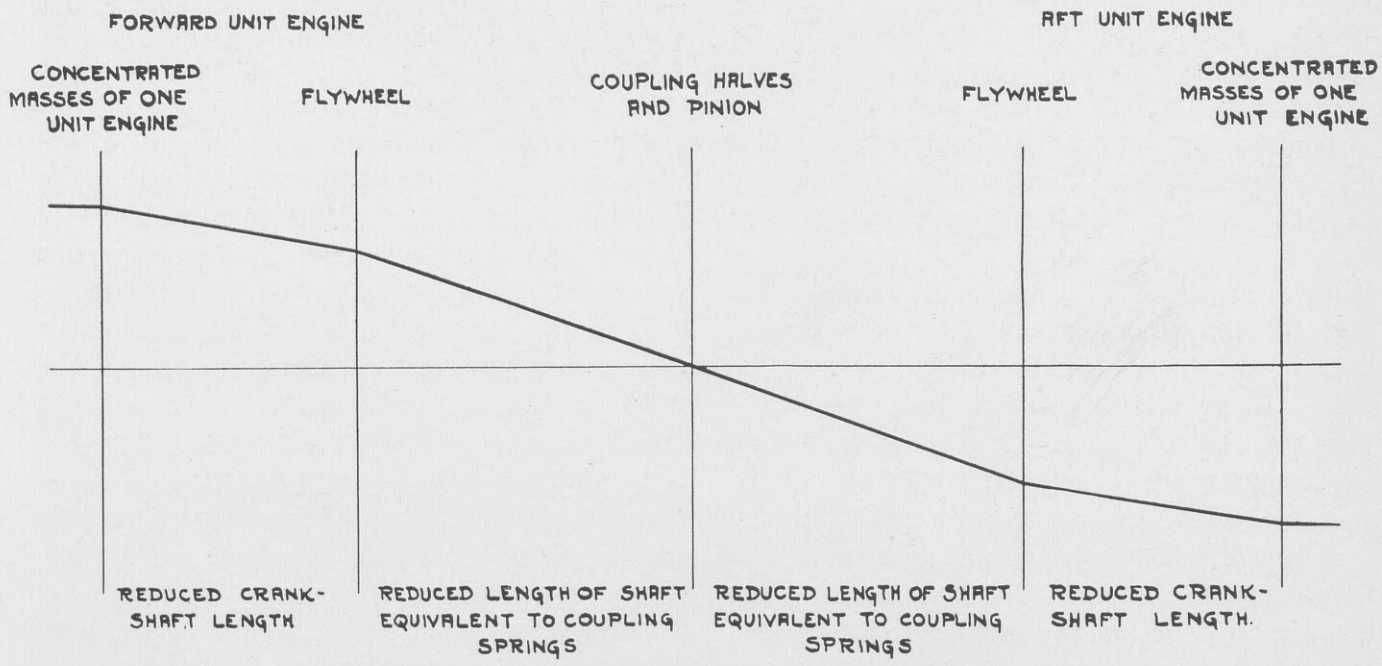


SHAPE OF TORSIONAL OSCILLATION AT THE FIRST HARMONIC,
OF ONE UNIT ALONE.
MAXIMUM AMPLITUDE IS SHOWN, PERIODICITY 2560 PER MINUTE.


FORWARD UNIT ENGINE
AFT UNIT ENGINE
CONCENTRATED MASSES OF ONE UNIT ENGINE
FLYWHEEL
COUPLING HALVES AND PINION
FLYWHEEL
CONCENTRATED MASSES OF ONE UNIT ENGINE
REDUCED CRANK-SHAFT LENGTH
REDUCED LENGTH OF SHAFT EQUIVALENT TO COUPLING SPRINGS
REDUCED LENGTH OF SHAFT EQUIVALENT TO COUPLING SPRINGS
REDUCED CRANK-SHAFT LENGTH.

SHAPE OF TORSIONAL OSCILLATION AT THE FIRST HARMONIC,
OF TWO UNIT ENGINES CONNECTED WITH COUPLING AND PINION.
MAXIMUM AMPLITUDE IS SHOWN, PERIODICITY 594 PER MINUTE.
THE FIGURE SHOWS THE ACTION OF THE COUPLING SPRING.

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Test Results of the Falk Marine Unit

Mechanical Efficiency, Including Gear is Over 80 Percent —Fuel-Consumption is 0.424 lb. per shaft h. p. Hour

ON the engine first completed, and subsequently on the entire Falk unit, very exhaustive and severe tests have been made. Mechanically every single part has proven to be very satisfactory under exacting conditions. Not one detail has ever failed.

MOST important of the features to be tested in the whole unit was of course the running of the reduction gear, which is entirely dependent upon the elastic conditions of the complete drive. As can be seen from the figures showing the shape of the lowest harmonic torsional oscillations, the engines themselves are well out of any danger from critical torsionals. The low speed drive has one critical only, which occurs at 27 revolutions. This speed is very low, and oscillations of such low frequency are not dangerous.

FROM the tests it has been conclusively proved that the very extensive research work has enabled a surprisingly smooth and soft-running gear drive to be produced. No sound or vibration is perceptible on the gear case even at considerable overloads. The extraordinary smoothness of this gear drive is perhaps the greatest surprise of the whole unit to any observer not intimately acquainted with the possibilities of the study of vibrations and their causes. Such an eminently satisfactory achievement is a very favorable augury for the bright future of the Geared Marine Oil-Engine Drive.

A NUMBER of torsiograms are shown on pages 54, 56 and 57, four of which were taken at the generator coupling and the remainder at the gear-flange. These latter are more important than the former, because the inertia of the generator rotor used in the tests is immensely greater than that of the propeller, and moreover, there is no dampening effect between gear and generator, while the dampening effect of the generator field is negligible compared to the dampening effect of the water at the propeller blades.

THE critical which shows at 27 r. p. m. is more evident at the generator end than at the gear end. In fact, the diagrams show that at 20 r. p. m., at the gear-end, only the fluctua-

Summary of Engine Tests

Duration of test	3 hours
Load of Generator	2,073 Electrical h. p.
Efficiency of Generator	92.5%
Load at Flange of Low Speed Gear	2,240 b. h. p.
Total Fuel-Consumption in 3 hours	2,851 pounds
Fuel-Consumption per b. h. p. delivered, per hour	0.424 lb. b. h. p. hour
Speed of low speed flange as per revolution counter	88.3 r. p. m.
Indicated horse-power, all four engines together	2,695.4 i. h. p.
Mechanical Efficiency of engines and gear	83.1%

	Starboard Engines		Port Engines	
	Fore	Aft	Fore	Aft
Exhaust Temperature °F	609.7	589.4	629.0	571.6
Cooling water °F	121.0	120.5	120.3	120.4
Indicated h. p	669.00	672.00	674.00	680.40

Temperature of:	
Cooling Water at Inlet	38.5° F.
Fuel Oil in measuring tanks	88.1° F.
Lubricating Oil at Inlet	98.0° F.
Lubricating Oil at Tank	103.0° F.
Pressure of:	
Lubricating Oil at Pump	15.8 lbs.
Lubricating Oil at Engines	8.1 lbs.

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Torsiograms Taken on Falk Oil-Engine Unit

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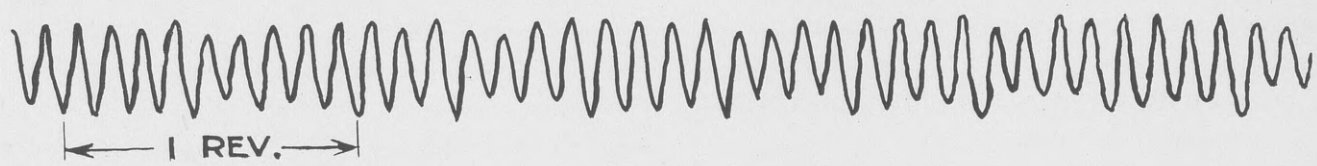
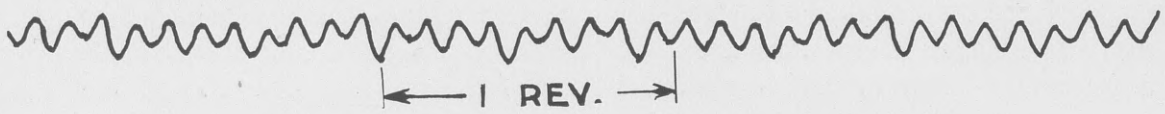
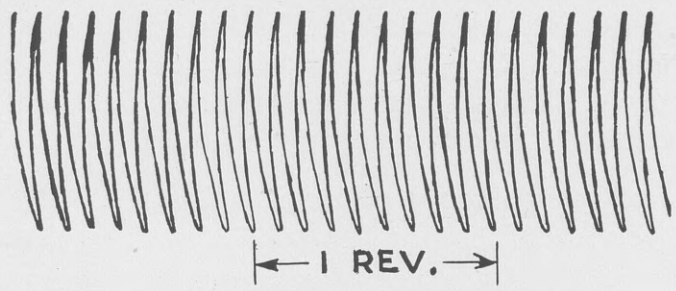


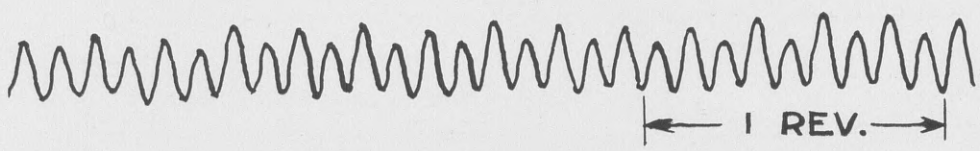
Graph at 20 revolutions per minute at the reduction gear plainly shows piston efforts



Record of oscillations at the gear with a speed of 25 revolutions per minute



Critical charted at the generator at 27 revs. per min.



Influence of the critical still existing at 30 revolutions per minute at the gear

Oscillations are of very slight magnitude at 40 revolutions per minute at the gear

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tions due to the piston efforts are indicated. At 25 r. p. m. the fluctuations begin to smooth out and at 30 r. p. m. the critical shows still a little. From there on, the gear runs with increasing smoothness up to 90 r. p. m., at which speed the running is very good. In taking the diagrams, the generator was set at 1575 k. w. at 90 r. p. m. and then the setting remaining unchanged the following readings were taken:

90 r. p. m.	1,575	K. W.
80 "	1,271	"
70 "	1,045	"
60 "	792	"
50 "	588	"
40 "	391	"
30 "	214	"
19 "	105	"

On the power trial, the whole unit was run for three hours at load and then a three hour test made. The generator was working on a rheostat consisting of cast iron grids submerged in a tank through which a stream of water was kept flowing. The load varied exceedingly little. Two sets of calibrated instruments were used for amperes and volts, the readings checking up very closely. The efficiency of the generator according to information from the maker was 92.5% at the test load.

For these trials a paraffine base Louisiana residue was used, which showed the following characteristics:

Gravity	27.4 Beaumé
Heat content (high value)	19,079 B. T. U. per lb.
Flash point	110° F.
Fire point	130° F.
Saybolt viscosity at 60° F.	330 seconds
Saybolt viscosity at 100° F.	75 seconds
Ash	None
Sulphur	0.14%
Water	None
Volatile matter at 212° F	21.6%

For the reversal tests, one of the two starting-air receivers was pumped up to 300 lbs. per sq. in. pressure, and the engine was reversed once every minute until the pressure was down to 111 lbs. per sq. in. when the engine refused to get under way again. This gave 30 complete reversals, which demonstrated the maneuvering qualities of the unit to be in every way excellent.

A full reverse from 2,200 b. h. p. ahead to 2,200 b. h. p. astern can be made in about 16 seconds with the present electric engine, but it could be expedited by a hydraulic servomotor or one of the Brown type.

Reversing is indeed the essence of simplicity with the Falk unit. The elements of the control were explained on page 42 and a brief reference made on the same page to the operations of reversing. One may here recapitulate the operations of starting and reversing, in order to emphasize how simple they are:

Start.
1. Set oil lever for 30-40% load.
2. Pull both air-levers and throw them back quickly, one after the other.

Stop.
1. Draw oil lever back for low load.
2. Pull reversing lever into "stop" position.

Reverse.
1. Set reversing lever into "astern" position.
2. Advance oil lever for 30-40% load.
3. Pull air-starting levers and throw them back.
4. Speed up with oil-lever.

One great advantage which has been incorporated in the design and which is of great importance to the operating engineer is the fact that the setting of the reversing lever shows the setting of the valve gear. A follow-up lever connected to the reversing shafts permits only a slight movement of the hand lever, which thus cannot be put in the 'stop', 'ahead' or 'astern' position without having the whole reversing system following its movements within an eighth of an inch. It is also possible to stop the movement of the reversing mechanism at any place, or reverse from any point of the movement in case an erroneous movement has been started.

A speed of 17 r. p. m. can be maintained without any cylinder missing.

After the conclusion of the tests the engine was put to work on the shop load, which varies between 1,000 and 1,200 b. h. p. at the coupling flange, with occasional peaks, during the day, and between 600 and 700 b. h. p. during the night. The lowest loads occur during

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Torsiograms Taken on Falk Oil-Engine Unit

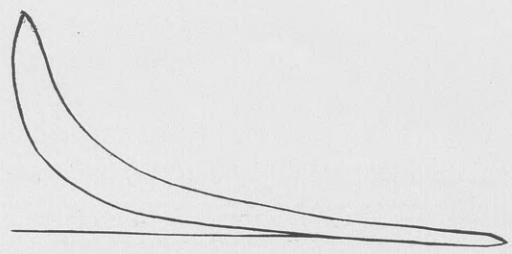
ENLARGEMENT: 3:1

At 50 revolutions per minute at the gear there is no trace of a critical

At 50 revolutions per minute at the generator the curve is very smooth

A flattening of the curve is apparent at 60 revs. per min. at the gear

Record at 70 revs. per min. at the generator



Indicator diagram: Mean pressure 84.5 lbs. per sq. in.

Scale: 500 lbs.

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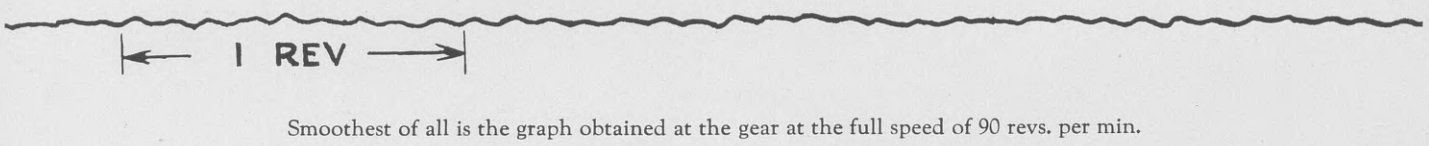
Torsiograms Taken on Falk Oil-Engine Unit

ENLARGEMENT: 3:1

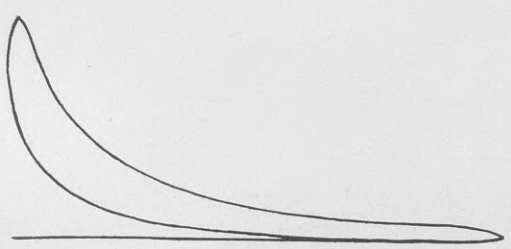
Very smooth running is evident at 70 revs. per min. at the gear

At 80 revolutions per minute at the gear the record is even slightly better



Smoothest of all is the graph obtained at the gear at the full speed of 90 revs. per min.

An almost straight line is shown at the generator at 90 revs. per min.



Indicator diagram: Mean pressure 89.2 lbs. per sq. in.

Scale: 500 lbs.

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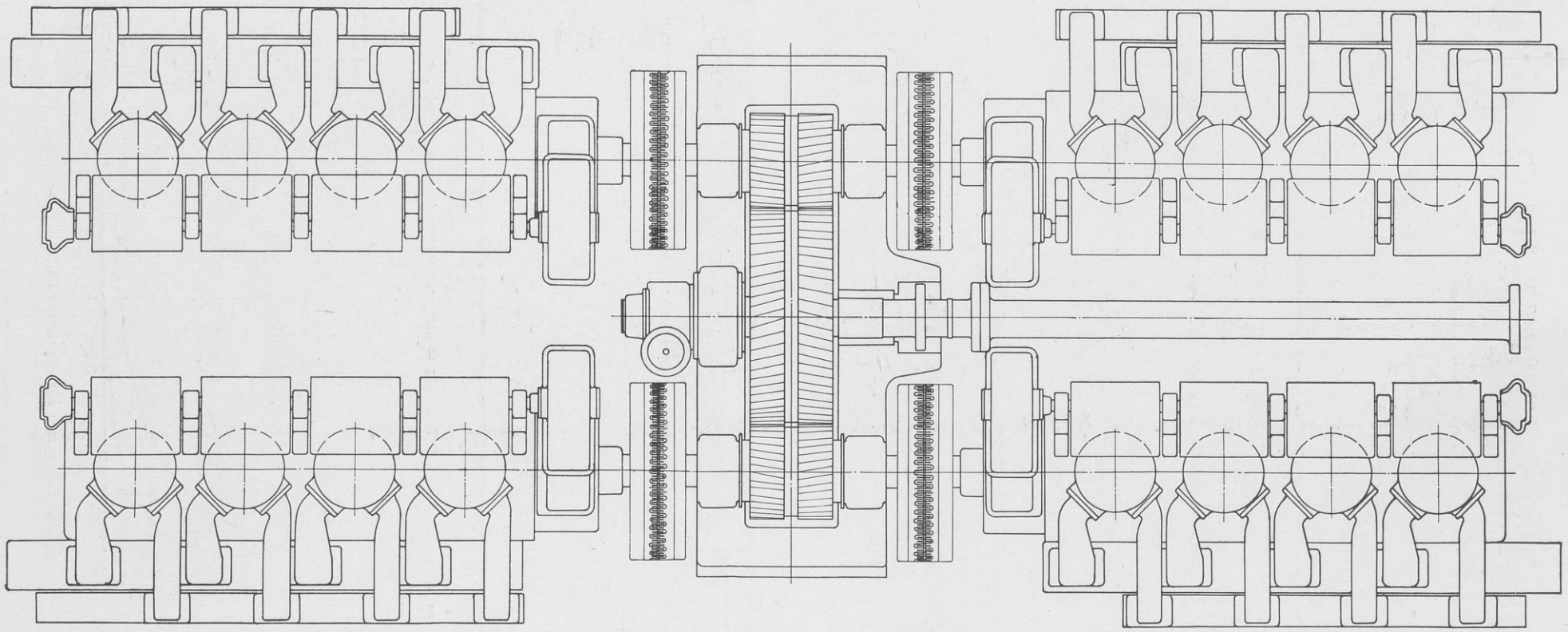

THE FALK OIL-ENGINE UNIT

Installation plan of the 2,200 b.h.p., 90 revolution Falk Marine Oil-Engine Set, showing the four engines, reduction-gear and spring couplings

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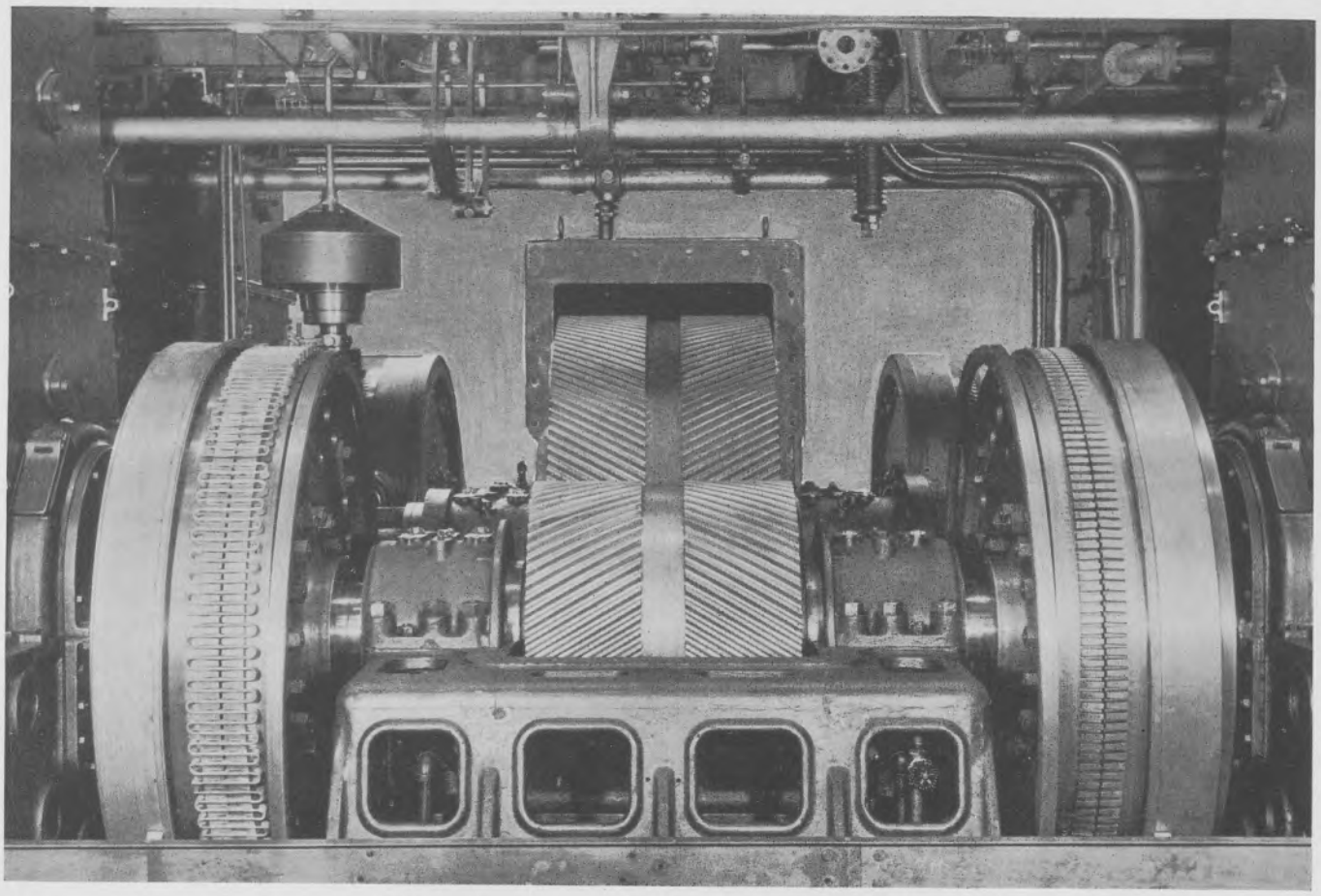
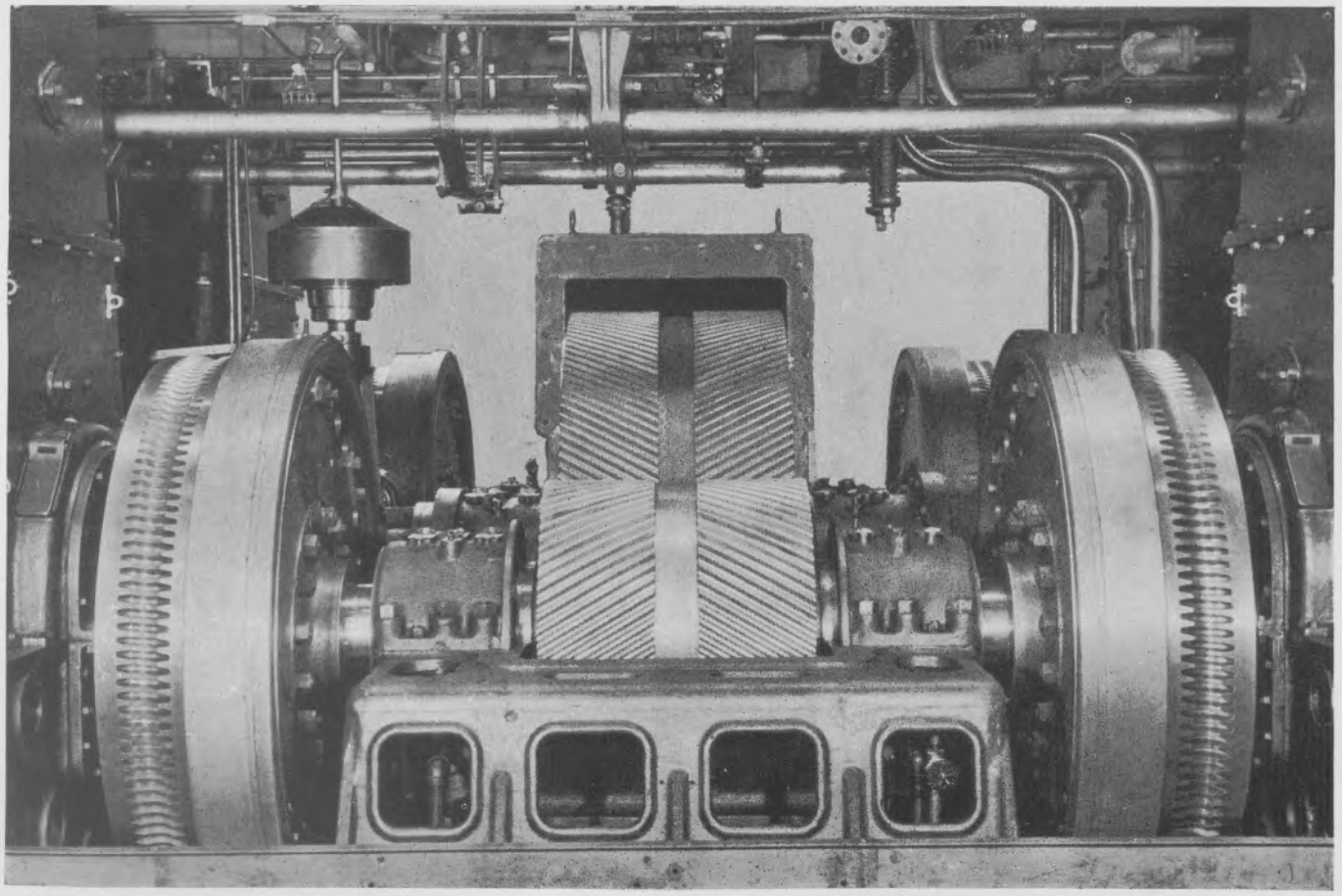


Falk Reduction Gear and Falk Bibby Couplings Uncovered



Same Reduction Gear and Couplings with the cover-band of the latter in place

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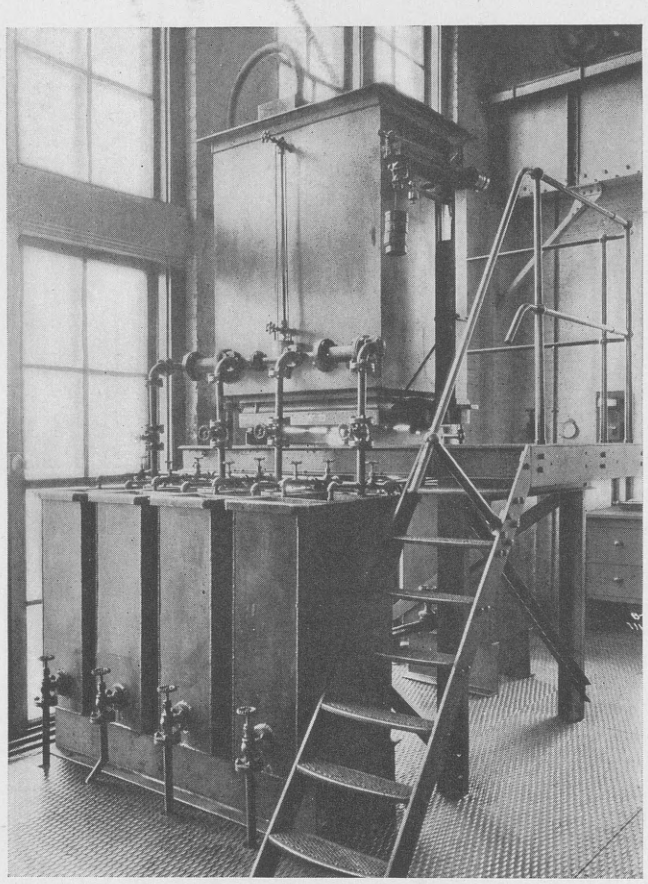
lunch hours, when only 240 b. h. p. is developed. After several weeks of operation of the whole unit, two of the engines were disconnected. The two remaining ones have taken the load very nicely, carrying loads up to 1,400 b. h. p. occasionally for an hour or so, without signs of laboring. The equal division of the load on the different cylinders is being maintained at all loads.

On a five days run on the shop load during which the load varied continuously between the limits just stated, the total operating time was 121 working hours during which 37,557 lbs. of fuel of the same quality as used during the test were burned. The power output was 570,800 k. w. hours which is equivalent to 822,500 b. h. p. hours at the low-speed gear flange. From these figures it will be found that the average load was 680 b. h. p. at the coupling, and the average fuel consumption 0.456 lb. per b. h. p. hour.

Lubricating oil consumption has been found to be 4 gals. in 24 hours, on two engines running as just explained. For a rating of 1,100 b. h. p. this would mean that 6,600 b. h. p. hours would be run on one gallon of lubricating oil (a grade of about 500 seconds viscosity is used for piston and bearing lubrication). A small quantity of Diesel oil has been burned, shop fuel otherwise being used exclusively. This fuel oil, as already explained, is used in the steel furnaces and a low sulphur content therefore is imperative, while freedom from water, ash, and other impurities is demanded and for winter use a zero oil. The fuels are mostly common Oklahoma, Louisiana, and other residue oils of from 26 to 30° B. taken from the works supply line. Low grade oils like Mexican reduced oils have been burnt with good results.



Measuring tanks for taking accurate fuel-consumption of engines on test—part of the thorough methods of The Falk Corporation

In conclusion it may be said that the expected early installation of this remarkable marine oil-engine unit in a ship will provide equally good results in service as have been given on tests at the Falk plant.

FINIS

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